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EDITORIAL.

ITEMS AND NOVELTIES.

An Immense Machine Tool.—In our last number we alluded to a Vertical Boring and Turning Machine of unusual dimensions, which we had seen just completed at the establishment of Messrs. Bement & Dougherty.

Want of space then prevented us from inserting a description of this remarkable piece of machinery, which we will now give with the accompanying plate, which will assist in making our description clear.* The uprights being movable, will allow an object of 23½ feet in diameter to be turned, while the greatest diameter for boring with the uprights in position is 12 feet, a height of 9 feet being also admissible.

The centre piece, or bed, weighing 26,000 pounds, is 10 feet 4

* It should, however, be remarked that this figure represents a machine to cut and bore but 12 feet; in the larger apparatus the dividing works are carried out 6 feet.

inches square, and supports the table by two bearings, formed by the anti-friction curve or curve of equal tangents. The lower bearing is in reality a continuation of the upper one; a portion of the curve being omitted on account of its great length, and the lower part of the curve is moved up so as to get the advantage of the two extremes of the curve with less depth of bearing. The largest diameter of the upper bearing is 6 feet 5 inches, and has 9¼ in vertical height; the smallest diameter of the lower bearing is 10½ inches, and has 24 inches vertical height. These bearings are lined with first-class Babbit metal (made at the works) after the bearings of the table are polished and set in the proper place on the bed, thus obviating the turning of the bearings in the bed.

The table is 8 feet diameter, weighing 14,000 pounds, on which is fitted a loose face-plate ring, 12 feet diameter, weighing 7,000 pounds. The table is driven by two sets of gearings. For fast motion, the table is driven from below by a pair of mitre-gears 34 inches diameter, 7 inches face. For slow motion a bevel-gear is cast under the table 94½ inches diameter, 7¼ inches face, into which gears a pinion, 11½ inches diameter. The hub of this pinion is a little larger than the outside diameter of the teeth, and runs in a bearing close up to the table, thus allowing the pinion to be drawn out of gear through the bearing, which is done by means of a nut connected with the pinion, and a thread cut on the driving shaft, when the table is to be driven from below.

The driving cone is 6 inches face, and has 5 changes from 17 to 34 inches diameter; the machine is back-geared; on the cone-shaft are two pinions which are brought into gear to drive the table either from above or below.

There are two cheeks, bolted on opposite sides of the centre-piece, to receive the uprights. They are 24 inches wide, 30 inches high, and 21 feet long, weighing 14,000 pounds each. They have planed grooves, into which fit corresponding projections under the uprights. The tail ends of the cheeks are tied together by a brace bolted between them.

The uprights are 13 feet 3 inches high, have a base of 8½ feet in length, and 30 inches in width, each weighing 11,000 pounds. The upper parts of the uprights are connected by a brace 3 feet deep, weighing 3,000 pounds. The uprights are moved together by screws driven by power.

The cross-slide is 33 inches high, 22 inches deep, with hollow curved back, and 15 feet long, weighing 11,000 pounds, and is

raised and lowered by screws driven by power through two tangent-wheels. There are two heads on the cross-slide, one for turning, facing and boring, with self-feed at all angles, and the other for drilling. The stand carrying the driving cone and back-gear for the drilling head is bolted on top of the brace connecting the uprights. The drill-spindle is steel, 4½ inches diameter, and has 18 inches travel, with self and hand feed.

The Dead-Stroke Hammer in England.—At the meeting of the Manchester Institute of Engineers, notice was taken of the Dead-Stroke Power Hammer of Messrs. Shaw & Justice, of this city. This hammer being a Philadelphia invention, we feel a natural interest in its reception abroad, and are glad to record the good opinions it receives. Mr. James Fletcher, of Manchester, who introduced the subject to the above meeting of engineers, in the course of his remarks, alluded to the many varied attempts which had been made to produce a power hammer that could be driven by a strap from a line shaft, and still possess all the essential qualities of a steam hammer, viz: to strike light or heavy blows, to run quick or slow, to be perfectly under control, and capable of being stopped instantaneously.

Mr. Fletcher stated that the Shaw & Justice hammer was one of those peculiar and simple inventions, so many of which have emanated from our cousins across the Atlantic; and that it possesses a great many advantages over all others; such as taking less power to drive it, so that he had no doubt that the same amount of steam which it takes to work a steam hammer, would drive by means of an engine, at least three of these hammers, each doing the same amount of work, for the reason that in the steam hammer, the entire cylinder must be filled with steam, even when a short stroke is made, thus causing a waste of power, which clearly does not occur in the other apparatus. Another merit mentioned was its simplicity in working, so that no instructions are necessary, but that any boy in a smithy can manage it.

The Illinois and St. Louis Bridge.—Report of the Engineer-in-Chief, James B. Eads, C. E.—We have read, with great interest, this pamphlet of portly dimensions, and shall, in a subsequent number, give some extracts from its most interesting portions, which want of space alone prevents us from introducing at the present time. In the meantime, however, we will make a general review of the work, and express freely our opinion both of agreement and dissent.

The entire report may be well considered in its two divisions of main Report and Appendix, the first being a general treatment of the subject, in a popular manner, for the benefit and instruction of stockholders and the non-professional public at large, and the last comprising a thorough analytical investigation of the whole problem. This latter portion, which is of the greatest interest to all professional engineers, Capt. Eads informs us, has been prepared by Messrs. Fladd and Pheiffer, of his staff, and to these gentlemen great credit is due for the masterly character of their work, displaying as it does a familiarity with the practical application of the higher analysis not often to be met with even among engineers, and without which no work like the St. Louis bridge could be intelligently designed.

Prof. Chauvenet bears his testimony to the accuracy of the calculations, and thus gives them the highest possible endorsement.

The problem involved in the consideration of an arched rib, is one of peculiar difficulty, especially when the rib is neither hinged at the crown or abutments. The method adopted is the one employed by Sternberg for the great ribbed arch over the Rhine, at Coblentz, the drawings for which appeared in our valued cotemporary, *Engineering*, some time since. Some modifications were necessary in the method of Sternberg, who treated the centre line of the arch as a parabola, and also considered the arch as *hinged* at the skewbacks. In the bridge before us, the ends were considered *fixed* at the piers, which reduced the computed deflections caused by the load under the hinged condition, allowing of a reduction of the weight of the material, provided a short distance from each end was strengthened. This last provision was required from the fact, that with fixed ends, the deflections were greater near the abutments than when the ends were hinged, and also because the effects from change of temperature were increased.

The ribs are formed from two circular flanges, separated about nine feet from each other by a system of triangular bracing. In this not only lies the carrying system, but it also contains the provision for counter-bracing, the spandril filling merely serving to support the roadway. The arch, therefore, acts in the double capacity of a rib under direct compression, and a beam under a transverse load, and the strains at each point are the resultants of the strains arising from the direct compressive action of the load, and from its bending action. Messrs. Fladd and Pheiffer have treated this question in a most thorough manner. The appendix is made complete

by lithographed sheets showing curves of strain under various conditions of the load, the whole forming one of the most admirable investigations of the kind that we have ever seen. We should mention that the full analytical considerations of the masonry are given, as also effects of wind upon the superstructure, and the gorging of ice against the piers.

The portion of the report written by Capt. Eads, is entirely descriptive, principally in defence of the plan determined upon, viz: three cast steel arches, of 500 feet span, in preference to any other, on the score of economy. His points are ingeniously and ably taken, but we do not think that the conclusions are always sound and reliable. We cannot speak too highly of the clearness and perspicuity of style in which the various subjects are discussed, and entirely agree with the reasoning adopted as to the relative economy of the arch and truss girder for long spans.

It will be remembered that, during the summer of 1867, Mr. Boomer called a convention of engineers, at Chicago, to consider the best plan of uniting the Missouri and Illinois shores by a bridge. He controlled a charter for the purpose, and was opposing Captain Eads, who also controlled a charter. This convention of Mr. Boomer's, after several days' deliberation, made a report upon questions involved in such a bridge, which was afterwards printed in pamphlet form, for distribution among those interested. The only style of bridge recommended, or even considered, was a truss, the maximum spans of which, it was agreed, should not exceed 368 feet. Commenting upon long spans, the convention declared, in their report, that there was no engineering precedent for spans of 500 feet, which would furnish them with any reliable data on the questions of material and workmanship in spans of such great length.

This was a direct and, as it appears, very inconsiderate stroke at the "Eads Bridge," and, in his report, Capt. Eads retorts by a description and drawing of the Kailinburg bridge, a truss bridge with a curved top chord, of the enormous span of 515 feet, precisely the span of the centre arch of the St. Louis bridge. The convention at Chicago avoided the consideration of the arch bridge; but Captain Eads does that work for them in his pamphlet, and handles the *ex parte* character of the convention very sharply.

The fact is, the convention only examined Mr. Post's style of truss bridge, and reported on that exclusively, as that was the de-

sign Mr. Boomer had decided to build upon before he called his convention together to take into consideration the best method of crossing. As they had, therefore, but one plan to consider, they reported rightly upon it, although it must be confessed that it was injudicious so to word their report that this limit of its bearing was not more apparent; if they had been permitted to discuss the subject of long-span bridges generally, without being confined to one principle of trussing, the result would have been of far greater value to the profession at large.

Captain Eads' case, we think, is not so strong, when he considers the question of the relative economy of suspension and upright arches. He claims that cast steel can be worked up to its *full* elastic limit when under compression, though only up to one-half its limit under tension. "If steel were but one-half stronger in compression than in tension, then two-thirds of the material only would be required to give the same strength in the upright arch that would be required for the suspended one. In that case, an upright arch having 1,000 tons of cast steel properly disposed throughout its length, would sustain as great a load as 1,500 tons in the suspended form." The reason assigned for this difference is, that a yielding, in the case of tension, means an utter downfall and destruction of the work, while in the case of compression, it implies only a mashing out of parts, and, therefore, an increase in section and resistance. This assumes, as it appears to us, that the mashing out has no injurious effect upon the structure of the material, an assumption which requires experimental proof. The number of experiments on the compressive resistance of steel are very meagre, although those in the tensional resistance are numerous. According to all existing authorities, *no* material should be worked up to its full elastic limit; and we cannot, without further demonstration, agree with Captain Eads in thinking it safe so to do. Engineers endeavor to keep far within this limit of elasticity, with good reason, we think, as Mr. Fairbairn's experiments on the impact of girders satisfactorily show.

We very much doubt if cast steel can be worked compressively to a better economical advantage than properly manufactured *steel wire*, although we admit that it has a manifest advantage over steel in the form of links, although not nearly so great as in Capt. Eads' estimates. A chain can be proportioned to the exact section theoretically required, while under compression suitable bracing, vertically and horizontally, must be introduced to prevent flexure,

beside the mechanical requirements necessitating an excess of metal for making proper connections of the several parts. It is one thing to compute the metal required in a structure from a simple diagram of strains, and another to arrange these parts to perform their duty, in combination with the practical requirements of actual construction. Parts in tension can almost always be worked up nearer to theoretical requirements than parts in compression. The extension of the cables to their anchorage forming the approaches, Captain Eads dismisses by the single remark, that a "less expensive method is *most* always practicable;" but he does not say that it is so in this case. As to the towers, he does not put them under the most favorable consideration, as he assumes the massive masonry required for an arch is carried up to form the towers, while it would be manifestly more economical to sink pneumatic piles, and have braced wrought iron towers upon them. As to the anchorage masonry, as compared to that required to receive the tremendous thrust of the land arches, we think there would be very little difference, especially if the masonry for the arches is founded in water, which would not be the case for the anchorage of the suspension bridge.

Calling the traveling platform the same in both, the suspension bridge requires a truss to enable it to conform to the conditions of equilibrium under a variable load. This truss would be a light one, and, perhaps, would not require any more material than the braced standards supporting the platform of the arched system, which are some fifty feet high near the abutments. The comparative cost of erection is largely in favor of the suspension is admitted without argument, it being just as well not to say too much about the difficulties involved in the erection of an arch of 500 feet span without false works, which Captain Eads must admit has no "engineering precedent," except in Telford's brain, and which he had no opportunity to carry out. We do not want to be understood as descrying the St. Louis bridge; we want to see it built, and we believe it can be. Further, we believe the spans proposed are within the powers of steel construction; but a comparison should be fair, and this we do not think has been quite the case in that made with the suspension principle. This, however, is quite natural, in view of Captain Eads' great difficulties in forwarding his scheme financially, and in view of a laudable ambition to build a steel arch-bridge of the greatest span hitherto attempted. We wish him all success, and hope that he will favor us and benefit the pro-

fession with a full account of his experiments upon steel, a machine for which, he informs us, he is having built.

The Southport Pier.—New method of sinking iron piles in sand. At the last meeting of the Franklin Institute, there was exhibited by means of a photograph projected on the screen, the structure of the Southport Pier, and the means used for sinking the piles on which it is supported. Both the structure and the process employed in its erection are remarkable for simplicity, economy and adaptation to the existing conditions.

This pier, capable of resisting severe strains from wind and water, as experience has proved, capable of sustaining a load of thirty-five tons for each bay, 3,600 feet long, and fifteen feet wide, with approaches, tool house, &c., was constructed for $46,595. The entire number of piles (237), were sunk in the space of six weeks in a location where work could be prosecuted only at low tide.

The methods employed for sinking were as follows: The lower ends of the piles were provided with circular disks one foot six inches in diameter, on which projections or cutters were cast, and through which, at the centre, passed a pipe delivering water from the regular mains under a pressure of fifty pounds to the square inch.

The pile was supported and lowered, as necessary, by a small piling machine, and a rotary reciprocating motion being given, the sand, &c. was loosened from beneath and carried away by the stream of water. The water being stopped, the pile settled, so as to sustain twelve tons without moving, in five minutes.

The Zentmayer Lens.—At a late meeting of the Franklin Institute, were exhibited a series of glass positives, made by Mr. E. Borda, from negatives which he had taken during the past season, with one of Mr. Zentmayer's lenses of 3½ inches focus, such as are supplied for stereoscopic work.

The subjects of these views were, as a rule, waterfalls and sheets of water found in the picturesque region of Pike Co., Penn'a.

The pictures projected on the screen, as usual, were of a most beautiful character, and elicited warm commendation from all present, doing honor equally to the skill of Mr. Borda, one of our most successful amateur photographers, and to the fine qualities of the lens. Mr. Borda also spoke in high terms of the ease of management, rapidity of working, and satisfactory performance of the lens. There were also exhibited on the same occasion, a num-

ber of large glass positives (shown with the large lantern having 8-inch condensers usually employed at the Institute meetings), of architectural subjects, of an excellence and beauty which we have never seen equalled.

When the first description of this lens appeared in a report of the Secretary of the Franklin Institute, published in this *Journal*, Vol. LII., p. 63, many of those interested in the manufacture and sale of other lenses, were loud in their ridicule of the whole affair as an impossibility, or a valueless device. Among these, the most prominent were the editors of the *British Journal of Photography*, who devised many "demonstrations" (which were no doubt convincing to themselves), that such a lens as we had described must require adjustment after focusing, and could not take a sharp picture.

From the following statement, published in their issue of Dec. 6th, 1867, we presume that they have reconsidered their conclusions.

"**Photographs produced by the Zentmayer Lens.**—We are indebted to our friend, Mr. M. Carey Lea, for a couple of fine photographs; one, a purely architectural subject, the other being as purely landscape. Although they are taken with a lens which is composed of only crown glass, yet the sharpness is quite equal to that of any we have seen by achromatic combinations of the usual kind; indeed, the limit to the appreciation of more detail seems to be the granularity of the paper, when viewed under a strong magnifier."

One energetic opponent has thus, we find, attained to knowledge and appreciation, and another, as we shall soon see, proves in a different way a like result.

Those interested in the globe lens, were in the first case, quite as skeptical as our English friends on the same subject, and though they did not commit themselves to print, yet did to paper to a like effect. But somehow, the Zentmayer lens did keep taking admirable pictures without adjustment of focus, and in fact, proved itself a great success and triumph of skill. Under these conditions, a Mr. C. B. Boyle, of New York, published a letter in the *Philadelphia Photographer*, October, 1867, claiming priority of invention. His claim was answered by us in the same journal for November. To this came a reply from Mr. Boyle in the January number, in which were published drawings stated to be reductions from his own and Mr. Zentmayer's patents. On comparison with the origi-

nals at the Patent Office, these drawings were found to be incorrect in several particulars, by which they were made to resemble each other, and this fact was accordingly published in the *Philadelphia Photographer*, March, 1868. Since this time, Mr. Boyle and his friends have left no stone unturned to worry Mr. Wilson, the editor of the above well known journal, into publishing some species of withdrawal or counter-statement to this exposure. These efforts have, however, proved fruitless.

It is therefore without surprise, that in a late number of *Humphrey's Journal*, which was sent to us, we find a large part of the pamphlet filled with abuse of Mr. Wilson. The authors of these discreditable personalities are in the first place, the editor of the journal and Mr. C. B. Boyle, before mentioned.

With regard to all readers of *Humphrey's Journal*, we should consider no answer needed to these attacks; their spirit and value would be justly appreciated, but as we have occasionally seen extracts from it in a foreign publication, which, feeling little kindness to this country, prefers to show to its readers our worst specimens, we insert for the benefit of our foreign friends and supporters a few words, which may put them on their guard, should the article be reprinted.

The charges contained in this paper are many of them simply childish slanders, such as an accusation of embezzlement of funds, for which a full account has been rendered and published. But there are others on which it may be worth while to speak. Thus, Mr. Wilson is accused of great unfairness in refusing to publish certain letters by Mr. Boyle, in which he sought to defend himself against a charge of publishing false drawings.

The reason why these letters were refused, we know positively, was simply this: The drawings *were* false, as is demonstrated by Mr. Boyle himself, in the article now noticed, (in which he gives one of his former drawings, and one reduced by photography from the same original, which are obviously unlike;) and the letters sent to Mr. Wilson were exactly similar in style and personality to that now published in *Humphrey's Journal*, and therefore obviously unfit for Mr. Wilson's magazine.

One word more. A report has been published by the New York Photographic Society, exonerating Mr. Boyle from the above charges. We have seen the original draft of this report, which was presented to the Society and acted upon. *It is in Mr. Boyle's own*

hand writing. The names of the committee having this matter in charge, have never been published, although the fact that a *committee was appointed*, is on record. In the meantime, we have in our hands certified copies of the original drawings and the published reductions, which are obviously unlike.

We, ourselves, having aided in opposing Mr. Boyle's claims, have been soundly abused, but we bear no malice on that account, and believe ourselves to be actuated in writing the above simply by regard for the cause of truth, and for a friend whom we have long known and respected.

ASTRONOMICAL DISCOVERIES.—Comets in the Spectroscope.—Brosson's comet, discovered in 1846, missed at its perihelion passage in 1851, seen in 1857, again missed in 1862, has been re-discovered in the present year, and submitted by Mr. Huggins to spectrum analysis with the most interesting results.

The two former comets which were examined in this manner by Mr. Huggins, showed from their nuclei luminous bands, closely resembling those of the gaseous nebulæ, while their comœ appeared to shine by reflected sunlight, giving only a subdued solar spectrum.

In the present case, however, the bright lines, three in number, and resembling those found by Donati in his own comet, are not confined to the nucleus, but are due also to the light from the coma, at least in its brighter parts.

In one of these bands, two bright lines were occasionally detected shorter than the bands, and therefore referable to the nucleus. A very faint continuous spectrum was also visible. It thus appears that nearly the whole coma of this comet is self-luminous, which, if it were possible to add anything to the intricacy of the question, What is a comet? adds its mite.

Proper motion of Stars measured with the Spectroscope.—That part of this motion which consists in the approach or recession of the star with reference to the observer, has been measured by Mr. Huggins in the following manner. The amount of refraction which a ray of light suffers, varies with its wave length. Thus, the violet waves of short stretch are much more refracted than the red ones, which are longer. If, then, by reason of a motion either in the earth or a star, the observer is carried towards the source, the apparent length of the waves will be diminished, and they will be more refracted; if, on the contrary, the star and earth are receding,

the waves will be relatively lengthened. Such a motion or change would cause the lines of the spectrum to be displaced, as compared with those in light from stationary sources. By observations based on these principles, Mr. Huggins finds that the nebulæ are neither approaching or receding, at an appreciable rate, and that the star Sirius is approaching our system at the rate of twenty-nine and a half miles per second.

This recalls an observation lately published, that when two trains are passing at speed, the note of the whistle sounded by one and heard in the other is higher on approaching, and lower after passing, than when at rest, or exactly opposite.

Spectra of Nebulæ Compared with Hydrogen.—Mr. Huggins and Father Secchi have found that when the spectrum of the electric spark was enfeebled by distance, it lost all its lines but the double one, which agrees in position with that observed in the nebulæ.

Spectra of Sun Spots.—Mr. Huggins repeating Mr. Lockyer's observations, finds that most of the dark lines are wider in the spectrum of the unbra than in that of the bright surface.

Eclipse.—The expedition sent to India to observe the Solar Eclipse of August, have reported by telegraph that they have met with great success and that the appearances shown in the spectroscope prove the luminous clouds seen around the sun, during total eclipse, to be gaseous.

Editorial Correspondence.

LETTER FROM MR. LATROBE.

PROFESSOR HENRY MORTON,

Editor of the Journal of the Franklin Institute:

Dear Sir:—I notice in the July number of the *Journal* just issued, some editorial references to the "Hoosac Tunnel," to which I must ask your attention, as they (no doubt undesignedly on your part,) place me in a position not altogether agreeable, the spirit of the remarks being likely to be misconstrued by your readers. Thus you speak of the success of the drilling machine, which soon fol-

lowed the recommendation in my report of December, 1866, that its further improvement should be prosecuted *outside* of the tunnel, which should meanwhile be driven by hand labor, as a "good joke" doubtless relished by my friends, &c. The meaning of this may seem to be, that while a young engineer might be excused for a want of foresight, such as was displayed by the failure in this case to see that success was so close at hand, in an old member of the profession it was scarcely pardonable. Now, if my report be referred to, it will be seen that, while giving the history of the drill at the Hoosac Tunnel up to that time, and the reasons for and against it as a labor-saving machine derived therefrom, I do not cast any doubt upon its ultimate success, nor even predict a lengthened period of trial before an effective machine would be secured.

Previous experience in the history of the power-drill, now going back twenty years or more, had shown but a succession of abortive efforts to make it a really useful and economical piece of mechanism, and I was not unwarranted in fearing that its past history might, to some extent at least, be repeated. I can scarcely then be found fault with, because success was so much sooner realized than there was reason to hope? It may be said that the Mont Cenis drill had already demonstrated a performance in Europe, which I should have known could as well be accomplished in America; but we had no right nor indeed the ability to use that precise machine here, for want of acquaintance with the minutiæ of its mechanism; and even in the absence of these difficulties, a feeling of national pride, and an ambition to devise something better, would have stood in the way of a servile copy of a foreign invention. I think, in short, that no one can read the remarks of my report of 1866, on this subject, without agreeing that the "joke" indulged in at my expense, is hardly legitimate, however innocently meant.

Again, it is inferred, that I am not a reader of the *Journal of the Franklin Institute*, because I was not aware at the time of my notice of the Michigan drill, in my recent report of 1867, that this drill was invented by Professor De Volson Wood, a conclusion drawn from very slight premises, as I think you will yourself admit. The fact is, that when I wrote this report, I had just returned from Europe, had been but once at the Tunnel, and the mechanic who showed me the drill only knew that it came from Michigan, without knowing the name of the inventor. Hence, I spoke of it as I did, and I may add that my mention of it was sufficiently favorable

to draw a letter from Messrs. Robinson & Wood, thanking me for the terms in which I had referred to it, and this led to some further correspondence, in which the causes (for none of which I could be held accountable), why the drill had not been allowed a fuller and fairer trial, were adverted to. As to my reading of the *Journal*, to which I have been a subscriber for very many years, and of which I have a complete set back to its first number, I must admit that occasionally, during long absences, certain articles do escape my attention, and among them, it so happened, was Professor Wood's upon the Hoosac drills, which appeared while I was abroad last year, and to which pressure of business on my return prevented me from going back. I presume that I am, on the whole, as regular a reader of the *Journal* as most of its subscribers, if I am to judge from what I hear from others in my profession; but I must allow, as will every fully occupied engineer, that to accomplish the perusal of even half the scientific periodicals of the day is no easy task, and therefore often imperfectly performed.

The differences of opinion between myself and one of the tunnel commissioners are spoken of in the editorial referred to, without any decided intimation as to who is right and who is wrong, but it is admitted that I have *shown* that the contract system recommended by myself has proved the most economical, and that the Legislature of Massachusetts has fully adopted my views on that point, is manifested by their recent abolition of the "commission," and by the requirement that no work after the 1st of October next shall be done upon the tunnel, except under contracts, proposals for which are now being received. In respect to the *pump* question, I have simply to say that I adhere to my opinion of the superior safety and economy of the Cornish engine, at the *top* of the shaft. The donkey pumps (as they are familiarly called), advocated and used at the *bottom* have indeed *luckily* kept the water from causing an absolute suspension of the work, because it has, thus far (contrary to every reasonable expectatien), rather diminished than increased in its flow; but it has been more than once on the very verge of drowning the donkeys, to say nothing of the enormously increased consumption of coal, costing $7 per ton, which they have required. It might not be difficult to show that, owing to the difference in this item, and in the repairs of the machines, the Cornish engines would have proved in less time than their services would have been required, *had they been applied at the proper time*, that notwith-

standing their greater first cost, they would have been the *cheaper* as well as the safer and more certain means of draining the tunnel.

I must ask, my dear sir, that you will let these remarks appear in the *Journal*, as much for the purpose of giving a correct account of the present state of affairs at the Hoosac Tunnel, as in explanation of what may seem to require it in my reports as its consulting engineer.

I am, very respectfully yours,

BENJ. H. LATROBE.

North Adams, Mass., August 12, 1868.

LETTER FROM THE ABBÉ MOIGNO.

Paris, September 1, 1868.

M. Hempel, the celebrated constructor and improver of philosophical instruments, to whom we owe great progress in electrical and pneumatic machines, delicate balances, &c., in following up an idea suggested to him by Professor Plücker, of Bonn, has greatly improved upon the apparatus known as the polarizer of Nuremberg. In the form that he has constructed it, the polarizer is composed of:— 1. A blackened glass, placed ordinarily horizontal, or more or less inclined at will, on which the incident ray is polarized by reflection. 2. A disc or ring, placed so as to support, on the path of the reflected polarized ray, the transparent plate which is to show the chromatic polarization. 3. A convex lens, which renders the ray, proceeding from the transparent plate, either parallel or convergent. 4. A new contrivance, which gives to the instrument an unexpected success, a parallel mirror of glass silvered on its exterior surface, fixed at such an angle, on a support, that it brings up to a vertical line the ray, doubly reflected and transmitted, and sends it into a Nicol's prism, which serves as analzyer, and turns on an axis. Whatever be the action exerted by this second mirror, all we can say is, that the phenomena of chromatic polarization, seen in this new instrument, are presented with incomparable intensity and sharpness of outline. For example, a model of a butterfly, formed of thin plates of selenite, of different thicknesses, presents by turning the analyzer, not only the two complementary colors red and green, orange and blue, yellow and violet, of well known polarizers, but all the shades of the spectrum, which succeed one another, with incredible clearness and brilliancy.

In order to demonstrate to the public at large, the visible rotation of the earth by Foucault's well known pendulum experiment, M. Maumené, in 1851, with the sanction of the late Cardinal Gousset then Archbishop of Reims, erected a large pendulum in the cathedral itself, and the experiments were several times repeated with the greatest success.

Now, Monsiegneur Landriot, present Archbishop of Amiens, has just authorized M. Maumené to reproduce in the cathedral of Amiens the same experiments that he made seventeen years ago in the cathedral of Reims. While we write, the preparations are being made with every care, and as speedily as possible, and M. Maumené, who constructed the Reims pendulum with his own hands, is having the same instrument erected at Amiens. He is ably assisted in this interesting work by M. Dubois, professor of mathematics, and M. Poiré, professor of physical science. The ball of the pendulum, without the envelope, weighs about forty-three and a half pounds. The suspending cord is of steel, and is upwards of 164 feet in length, the available height inside the Amiens cathedral being 165 feet. The diameter of the circle of oscillation is to be nineteen feet five inches. Under these conditions, spectators can be convinced by eyesight, on watching the motion of the pendulum, for only half an hour, that the earth does go round on its axis and no mistake.

F. Moigno.

THE REWARD OF GENIUS.

There is no market for genius. To conduct such a market requires the highest order of talent, combined with a full purse at the outset; and as the two are rarely combined, genius must go begging, or be dependent on slight favors, when it often possesses that, which, after its death, is found to be worth millions to the community. And this will ever be: so long as genius continues ahead of its time, it necessarily leaves those who are incompetent, so far behind.

New discoveries or inventions are not saleable until they are understood; and to have it known, it must be taught, which requires often repeated explanation and frequent illustration, consuming nearly all the time of the man of genius, which is generally spent without any equivalent. Great truths, like great medicines, are sometimes quite sharp and unpalatable. T. S.

Civil and Mechanical Engineering.

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

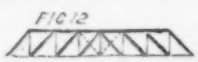
By G. S. Morison, C. E.

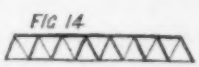
(Continued from page 105.)

Construction of the Web.—The simplest form of web is a thin sheet of metal extending from chord to chord, as in I beams, and the different varieties of plate girders; but the action of the strains within such a web is but imperfectly understood, and so great an excess of metal is required to prevent buckling as to render it, except in very small structures, far from economical.

The function of the web is to resist the shearing strains by conveying the weight applied at each point to the supports. This will be effected by a series of bars running from chord to chord, and thus connecting the ends of the beam by a zigzag line. A weight applied at any point of the truss will travel on these bars from chord to chord, and so reach one of the supports. As weight always exerts a downward force, the bar on which it travels from upper to lower chord will be strained in compression, and that on which it travels from lower to upper chord in tension.

The bars may be so arranged that the load shall advance towards the supports when travelling from upper to lower chord, when travelling from lower to upper chord, or in both cases. In the first case, the tension bars or ties will be vertical, and the compression bars or struts inclined (Fig. 12); in the second case, the struts will be vertical, and the ties inclined (Fig. 13), and in the third, both struts and ties will be inclined. (Figs. 14 and 15). The first arrangement is that adopted in the common Howe Truss, the second that of the Pratt Truss, and the third in which struts and ties are equally inclined, that of the Warren Girder. The bracing of the web may also be arranged in two or more systems (Figs. 16, 17, 18 and 19). In this case, each system bears its own share of the weight independently of the others. Fig 19 is simply a Warren girder developed into a lattice.





It may be noticed that in an open truss, any rupture due to the

shearing strain would extend through the length of a panel, which would thereby be distorted. That this is precisely analogous to the sliding of one part upon another in a solid beam, will appear from Fig. 20.

FIG 15

Through that part of the beam in which the shearing strain is positive, the weight must be conveyed to the left hand support, the struts, if inclined, will then lean to the right, and the ties to the left; when the strain is negative, the weight is to be carried to the right hand support, the struts leaning to the left, and the ties to the right. As the sign may change anywhere between s and s′, Fig. 11, between these two points the web must be capable of carrying the strain in both directions. This will be effected in the first and second arrangements of web by introducing counter-bracing, as shown by the dotted lines in Figs. 12 and 13; in the third arrangement by making the bars of the central panels capable of acting both as struts and ties; in that arrangement in which the ties and struts are inclined unequally, either method may be used.

FIG 16

FIG 17

FIG 18

FIG 19

The distance on either side of the centre to which counter-bracing need be carried, can be calculated by the formula already given, and is dependant solely on the ratio between the dead and moving loads. Table I. gives the distance in decimals of the whole length of the truss, through which counter-bracing is needed on each side of the centre for several values of this ratio. It can rarely happen that the dead load will be as great as in the three or four values at the head of the column, but they serve to show how slowly the length of counter-bracing decreases in heavy bridges, and how little stiffness can be gained by the expensive plan of ballasting. When the point s falls between the centre of a panel and the end of a truss, no counter-brace is needed in that panel, but it is well to put one in as a precaution against the possibility of an excessive load. Beyond this limit, counter-bracing, unless used as in the Post and McCallum bridges, to create an artificial stiffness, is abso-

FIG 20

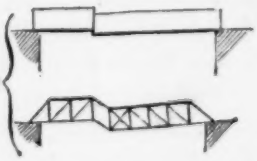
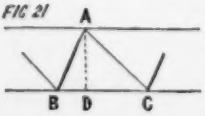


FIG 21



lutely useless, the strain on the main brace necessarily throwing the counter out of adjustment.

In determining the most economical arrangement of the bars composing the web, the relative inclination of struts and ties, and the length of panel must both be examined.

I. To find the most economical relative inclination of struts and ties. In Fig. 21, let BA represent a strut, and AC a tie, then

$AD = a =$ depth of truss.
$BC = b =$ length of panel.
$BD = c =$ inclination of strut.
$DC = b - c =$ " " tie.

$AB = \sqrt{a^2 + c^2}$ $\quad AC = \sqrt{a^2 + (b-c)^2}$

By varying c between 0 and b, Fig. 21 will be made to embrace the several arrangements of Figs. 12, 13 and 14.

The strains in the braces being produced by a force acting vertically, will be proportional to their lengths, and if m denotes the weight or value of a section of the strut capable of sustaining a unit of strain, and n the corresponding section of the tie, then the weight or cost of the strut is proportional to

$$m\,(a^2 + c^2)$$

and that of the tie proportional to

$$n\left(a^2 + (b-c)^2\right)$$

and that of the two braces proportional to

$$m\,(a^2 + c^2) + n\left(a^2 + (b-c)^2\right)$$

The minimum value corresponds to the case when the differential co-efficient taken relatively to c vanishes, or

$$2\,m\,c - 2\,n\,(b-c) = o$$
$$c = b - c = n : m$$

Hence the most economical division of the panel is that which makes the inclination of tie and strut, in the inverse ratio of the weight or value of material required in each to sustain a unit of strain.

II. To find the most economical length of panel. The whole

TABLE I.

Ratio of dead to moving load.	Length of counter-bracing on each side of centre.
10	·012 *l*
5	·023 *l*
4	·028 *l*
3	·036 *l*
2	·051 *l*
1·8	·055 *l*
1·6	·060 *l*
1·4	·067 *l*
1·2	·075 *l*
1·	·086 *l*
·9	·092 *l*
·8	·100 *l*
·7	·109 *l*
·6	·120 *l*
·5	·134 *l*
·4	·152 *l*
·3	·176 *l*
·2	·210 *l*
·1	·268 *l*
0	·500 *l*

material in the web is in the direct ratio of the material in each panel, and the inverse ratio of the length of panel, and proportional to

$$\frac{m(a^2+c^2)+n\left(a^2+(b-c)^2\right)}{b}$$

For the first arrangement (vertical ties), $c=b$, and this fraction becomes

$$\frac{(m+n)\,a^2+m\,b^2}{b}$$

which is a minimum when the differential co-efficient taken relative to b vanishes, or when

$$m-\frac{(m+n)\,a^2}{b^2}=o$$

$$b=a\sqrt{\frac{m+n}{m}}$$

in which case the whole material in the web is proportional to

$$2\,a\sqrt{m\,(m+n)}$$

For the second arrangement (vertical struts), $c=o$, and the web is proportional to

$$\frac{(m+n)\,a^2+n\,b^2}{b}$$

and this is a minimum when

$$b=a\sqrt{\frac{m+n}{n}}$$

the whole web being then proportional to

$$2\,a\sqrt{(m+n)\,n}$$

For the third arrangement (ties and struts equally inclined), $c=\frac{1}{2}\,b$, and the web is proportional to

$$\frac{(m+n)(a^2+\frac{b^2}{4})}{b}$$

and this is a minimum when

$$\frac{1}{4}-\frac{a^2}{b^2}=o \qquad b=2a$$

the web being then proportional to

$$a\,(m+n)$$

(To be continued.)

STEAM-ENGINES OF THE FRENCH NAVY.

By R. H. Thurston, U. S. N.,

(Member of the Institute.)

A peculiarly ingenious modification of the "Woolf system" of steam-engines has recently been extensively introduced into the French iron-clad navy, with the expectation of securing a marked economy in consumption of fuel and other advantages.

In this design, three cylinders of equal size are set side by side, and coupled to the same crank-shaft. These cylinders are precisely alike in every part, and their pistons, rods, and valve gear are all cast from the same patterns, and forged from the same drawings, and the distribution of steam is ingeniously arranged in such a manner as to throw nearly equal work upon each cylinder, the high pressure cylinder receiving the same maximum strains as the low pressure cylinders.

In the first of these designs, the cranks were set at angles of 120° with each other. The steam, moderately superheated, passed through the steam jackets of the two condensing cylinders, and entered the high pressure cylinder which was placed between the other two. In the high pressure cylinder, steam followed the piston until the crank had swung through 120° of arc, when the valve closed the steam port of the middle cylinder, which we will call A, and at the same instant, a condensing cylinder, B, commenced taking steam from A, the steam expanding in both cylinders.

As A commenced its return stroke, it would compress the steam remaining in A, but at that time, the piston of the condensing cylinder, B, travelled so much more rapidly than that of A, that it compelled a continued expansion; when the crank of B had passed over 120°, or when that of A had moved through 240°, B closed its steam port, and the other condensing cylinder, C, took steam from A, until the latter reached its dead point; there the valve of C closed its port, while A took steam again. A reservoir was at first interposed between the high pressure and the condensing cylinders, into which the steam was exhausted from A, and from which the other cylinders took their steam. It was found to have no useful effect, and was afterwards removed.

In later engines, the cranks of the two condensing cylinders are set at an angle of 90° with each other, and that of the high pressure cylinder 135° from either, while the point of cut-off is fixed at

or within half stroke for the high pressure, and at three-quarters for the condensing cylinders.

Figs. 1 and 2 exhibit the pressures on one side of the piston, in each cylinder, during a complete revolution, in each of these styles of engines.

The full lines *a a a a* represent the pressure in the middle cylinders, and the broken lines show the pressure in the condensing cylinders, the ordinates representing the pressures, and the abscissas measuring degrees of arc.

L L is the line of atmospheric pressure; the dotted line exhibits the back pressure in cylinder A, and affords a ready means of comparison of the amounts of work done in each cylinder. The back pressure line of the condensing cylinders is taken at 13½ pounds below the atmosphere. It will be noticed that in the later engine, whose curve is given as Fig. 2, steam enters cylinder A from the boiler, until the crank has passed over 90°; from 90° to 135° steam expands in A; from 135° to 225° it expands in A and B; from 225° to 255° it expands in A, B and C; from 255° to 345° it expands in A and C, and is compressed in A during the last 15° of the revolution.

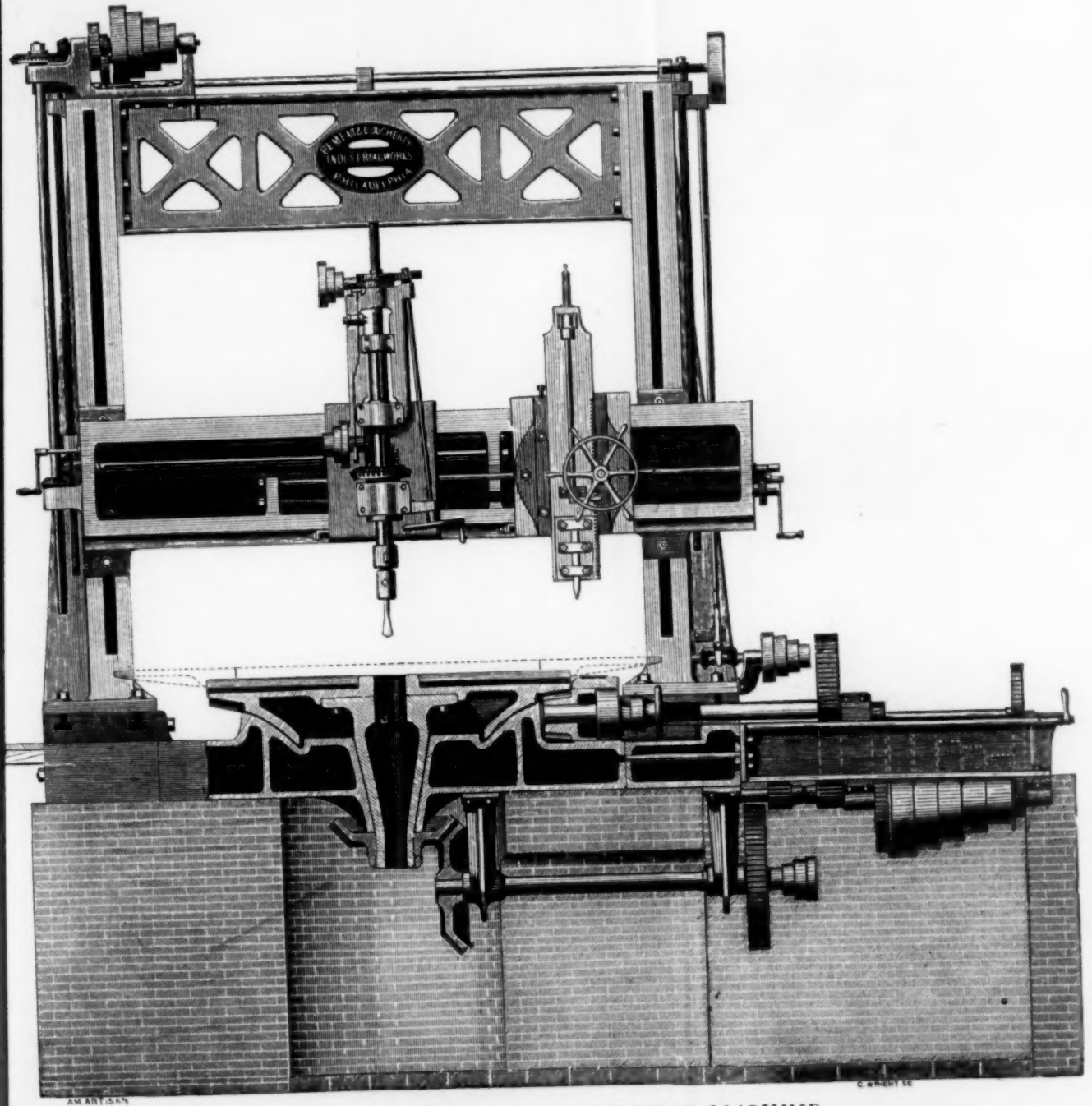
The amounts of work done in the several cylinders are very nearly equal, and the *maximum* pressures on the crank pin are almost precisely the same.

It will be noticed that at some portions of the revolution, where steam is expanding in the middle cylinder and one of the side cylinders simultaneously, the full line of the middle cylinder *a a a* coincides with and hides the broken lines *b b b* and *c c c* of the side cylinders.

The designer claims for this engine superiority in economy of fuel, nearly perfect static equilibrium, great length of bearings with moderate pressures upon them, and economy in first cost and in repairs.

Engines of this pattern were exhibited at the Paris "*Exposition*" of 1867, and attracted much attention from engineers who have looked with interest for reports of performance.

Those engines, intended for the *Friedland* and the *Ocean*, were of 82⅝ inches diameter of cylinder, 4 feet 3¼ inches stroke, and drive a Mangin screw of 20 feet diameter, and 28 feet of pitch; they were rated at 960 nominal horse-power, and were intended to work up to 4,000 indicated horse-power; their weight was about 400 tons, and



VERTICAL BORING AND TURNING MACHINE.

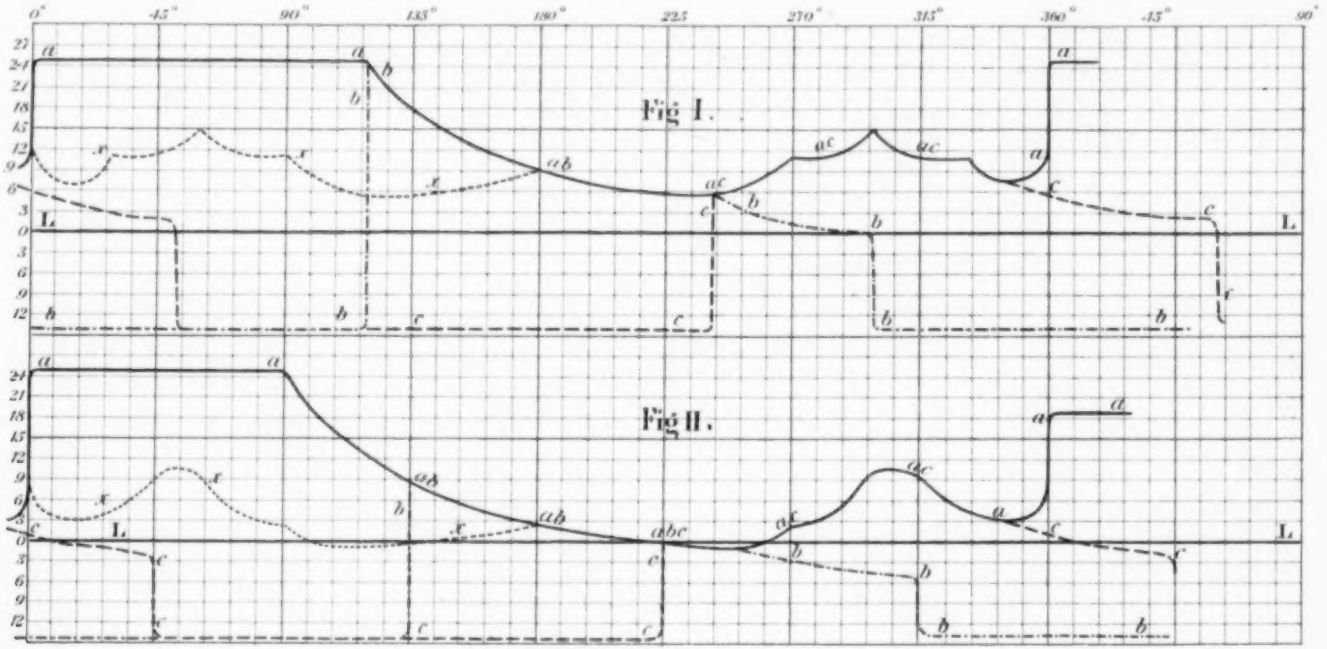


Fig I.
Fig II.
0° 45° 90° 135° 180° 225 270° 315° 360° 45° 90°
L

with boilers ready for steam, something over 800 tons; their cost was about $300,000, gold.

They were intended to drive iron clads of 7,000 tons displacement 14½ knots per hour; their duplicates have not worked up to as high a power as was intended, but a speed of 14·2 knots is claimed.

In 1863 a board of officers was directed to conduct a series of experiments with the engines, then just completed from the new designs, for the *Loiret*, and to report upon the relative economical value of the old plan with two cylinders and the new style.

The experiments, seven in number, of twelve hours each, exhibited an economy of from 3 to 7 *per cent.* in favor of the new engine.

The result for the two cylinder engine was obtained by simply removing the valves from the middle cylinder, thus using the two condensing cylinders under some disadvantages, and probably appreciably exaggerating the relative value of the new design.

The Board reported that they considered it advisable to make a trial of an engine with three cylinders, but each taking steam direct from the boilers, in competition with the *Loiret* engine.

Such engines were accordingly fitted to the iron clads *Gauloise* and *Revanche*, and their performance compared with engines of the new type fitted to the iron clads *Magnanime*, *Savoie* and *Valeureuse*.

The vessels were all similar, displacing 5,711 tons; their length was 262½ feet, breadth 56 feet, and draught of water 25¼ feet; their engines were intended to develop 4,000 indicated horse-power.

The engines of the *Gauloise* type cost *two-thirds of one per cent. less* than the *Savoie* style.

The following table exhibits the result of their trials:

Name.	Engine Builder.	Date.	Style Engine.	IHP.	Coal per H. P. per Hour.	Pres. Steam.	Saturation.	Rev.
Gauloise	Mazeline	Aug. 1867	Three Independent Cylinders	3,639	3·02	16½	2·57	56·3
Revanche	Forge et Chantiers.	July, 1867		2,554	3·23	13½	.....	52·
Magnanime	Mazeline	June and July, 1866	Dupuy de Lome's Modification of the "Woolf System."	3,506	2·85	29	.....	54·66
Savoie	Forge et Chantiers			3,326	2·83	28	2·43	54·
Valeureuse	Indret	May, 1866		3,197	3·37	30	.....	54·1
		Aug. 1867		3,467	3·10	27	2·42	55·4

The point of cut-off in the *Gauloise* engines was fixed at *four-tenths;* the *Magnanime* expands about four times.

Neither of these engines worked up to its intended power, and neither exhibited surprising economy of fuel, the two styles being about equal in that respect.

A member of the Board which has been mentioned, has recently published a pamphlet in which he analyses the claims advanced by M. Dupuy de Lôme, in a "*Note*" to the *Revue maritime et coloniale*, and his ideas accord so well with those of many of our own engineers, that we translate in full his

CONCLUSIONS.

Comparing this new engine—derived from Woolf's system—with the ordinary engine with two cylinders, we see by experiments before referred to, that the latter (under exceptionally disadvantageous conditions, however, as in the *Loiret*), exhibits from 3 to 7 *per cent.* greater consumption of fuel, a fault slight in itself, and which is certainly more than compensated, *for a war vessel*, by the advantage of employing for the same number of revolutions of the screw, a much lower pressure in the boiler, and, consequently, of being less exposed to incrustation, which takes place so rapidly at high temperatures, and of being less liable to dangers that accompany ultimate rupture, and by the further advantage of being able to steam at much lower speed, if it is desirable not to reduce the pressure.

The *maximum* strains upon the crank-pins are greater in the engines with two cylinders. However, they are not *double* as the author of the "*Note*" asserts; the difference is only about *ten per cent.* On the other hand, the uniformity of the "couple of rotation" is more satisfactory in the engine with two cylinders; the latter, at lower cost, is of less weight, and occupies less space, thus presenting an important advantage where excessive thickness and weight of armor-plating interpose such great obstacles to the full and *effective* protection of the vital part of war vessels.

Since the working pressures are very different in the two styles of engines, developing the same power, it follows that, as the boilers deteriorate and it becomes necessary to reduce the pressure, this reduction will be a greater disadvantage to the new engine than to the engine with two cylinders, as it will affect the former only until the working pressure of the engine with two cylinders is reached, during all of which time its power will decrease, while the two-cylinder engine will retain its power.

We see then, by comparison of the respective advantages and disadvantages of the two engines, that the superiority attributed by its designer to the new machine over that with two cylinders, is perfectly debatable.

But if we compare the new engine of the *Savoie* type with the engines with *three independent* cylinders of the *Gauloise* type, we may conclude, from the preceding discussion, that the *latter* are in every respect superior.

In fact: 1. They are equal to the other in respect to economy of fuel, and besides, they have, with less, by 12 pounds, boiler pressure, worked up to a power greater by nearly 400 horse-power.

2. They afford greater security on approaching a high velocity of rotation, because their "couple of rotation" is more regular, their maximum pressure on their bearings is 50 *per cent.* less, and because the cutting caused by high temperature of steam is less to be feared.

3. The statical equilibrium of their reciprocating parts is more perfect from the more regular manner in which the cranks are set on the shaft.

4. To obtain 4,000 horse-power with these engines, a lower velocity may be adopted than is proposed for the engines of the *Friedland*, by raising the pressure, without, however, approaching 26 pounds, or by extending the introduction, while with the *Friedland's* engine that power cannot be obtained, unless by exceeding the working pressure—26 pounds—or by increasing the velocity of rotation, which is already too great.

5. Finally, as the point of cut-off in the *Gauloise* type is only at ·40, when the boilers become worn, a lower pressure may be used without lessening the power, by allowing the steam to be cut off later; this would be impossible with the new engine, where the introduction is already at its maximum.

En résume, the three advantages attributed to the new engine by its designer, in comparison with the engine of two cylinders—which advantages we have reduced to their true value—become, on the contrary, so many points of marked inferiority in comparison with the three cylinder engine of the *Gauloise* type, which latter possesses the highly important advantages referred to in paragraphs 4 and 5 above.

This engine, on the modified Woolf type, is therefore far from exhibiting an "important advance" as the author of the "*Note*" announced.

In fact, its greatest defects may pass unnoticed in time of peace, because those occasions on which the engines of our war vessels are required to develope all their power, are then very rare and of short duration; but in time of war, for which those vessels are constructed, a speed that calls for high pressures and speeds of piston, will be often demanded and obtained. Then the great dangers that these engines bring with them will be made evident.

In presence of such contingencies, there will be no hesitation in altering these engines as promptly as possible into machines of the *Gauloise* type, which can fortunately be done without difficulty.

The latter style of engine has been introduced into the English navy, and the *Loiret* commission, in recommending it, in 1863, in preference to that which the "*Note*" would have us accept to-day, pointed out to the administration one of the best courses that it could pursue.

It was this that we have attempted to prove, and we believe that we have offered full evidence of the fact.

(Signed) H. LABROUSSE.

Since the date of the above criticism, the French engineers have definitely adopted surface condensation in the new type of engine, with a view to the avoidance of the rapid deposit of incrustation due to the higher pressure, but the other objections remain and will probably prove fatal to this style of engine, in spite of the advantages it possesses of equalizing and lessening the strains upon the bearings, reducing initial high pressures where high steam is used, and affording large bearings, as well as the economical advantage of similarity of parts in its several cylinders and their appurtenances.

Providence, R. I., July, 1868.

CUTTING AND PLANING STONE.

By S. W. ROBINSON, C. E.

MANY attempts have been made to dress stone of various kinds by the action of a cutting tool passing over them, as in planing or turning iron, wood, &c. Very many of these attempts have failed mainly for the reason that the grit of most stone will not admit the passage of any tool, which can be economically used, without its

suffering too severely from the grinding action of the stone. Nothing but the diamond can act in this manner upon stones, which are most difficult of being so cut, such, for example, as granite, quartz, &c. But the diamond is too expensive for common use.

Other varieties of stone, such as gypsum, soapstone, slate, &c., are, on the contrary, easily cut with a steel-tool in the manner above described. Limestone is more difficult; and sandstone, even if it be softer, is yet less easily cut on account of the grit. There is, therefore, a certain limit beyond which this mode of acting upon stone must cease

It is well known that blows upon a steel tool, when in contact with a refractory stone, will flake off particles without seriously injuring the cutting edge. This is the mode of action of the common drill in boring blast holes; also of the stone mason's dressing chisels. This principle for cutting stone may also be brought into action by rolling a circular cutter, under heavy pressure, over the surface of the stone. The cutter being free to revolve, so as to relieve its edge from slip, presents a sharp edge to the stone throughout its whole periphery. A very hard steel cutter may thus be made to act upon glass, leaving heavy traces to mark the passage of the tool.

A combination of the two methods of cutting above described, has been tried for cutting stone which could not be cut by the first named process. Near the eastern portal of the Hoosac Tunnel, in Massachusetts, may be seen a hole about 16 feet deep, horizontally, and 24 feet in diameter, which was bored into the solid talcose slate of the Hoosac Mountain by an immense tunneling machine in the earlier days of the present Hoosac Tunnel enterprise. The surface of the rock, as left by this remarkable machine, is as smooth as though dressed to an even cylindrical surface by masons' chisels. The machine which did this work was provided with revolving cutters, the axes of which were set diagonally to the path of their motion, so that the cutting was due partly to the rolling contact, and partly to slip. This machine was unsuccessful, as is shown by the fact that it was intended to bore through the mountain, but only made about 16 feet advance before being abandoned on account of the expenditure of one set of the circular cutters, which were very costly. A tunneling machine was tried in England which cut its way 80 feet into rock, but was not regarded as successful.

At Lemont, Ill., may be seen a massive planer, constructed of

iron, on which immense flagging and facing stone are planed to a remarkable degree of smoothness, presenting, in fact, almost a polished surface. The stone thus treated is limestone, from the magnesium limestone beds in the vicinity of Lemont, from which many of the excellent building stone of the city of Chicago are quarried. The stone to be dressed is purchased at the quarries by A. T. Merriman & Co., planed, and sold at an advanced figure. The stone is planed in a manner similar to that of planing iron. A series of cutting tools are fixed, under which the stone moves to and fro with a great degree of power and steadiness, the cutters taking off shaving after shaving until the desired quality of surface is obtained. The edges of the stone are also squared down, and grooved to receive an iron tongue to break joints, and cause the fronts of any two or more consecutive stones to lie in the same plane. A very slow speed is required to plane this limestone in order to preserve the cutting edges of the tools for any considerable length of time. This limestone is quite hard, and figures among the strongest of building stone, but having less real grit than many other kinds of stone is still susceptible of being reduced to shavings by steel tools and skilful management.

Sandstone, from which grindstones are produced, being very gritty, can best be turned and dressed for the market by tools which are changed into various positions by special manipulation, as they are ground away, so that a sort of rude cutting edge is being continually formed and brought to bear upon the the grit. This method of procedure is adopted at the works of Barea, Ohio.

A very good tool for renewing the surface of grindstones by turning, when worn by use, is simply a round rod of soft iron about one-fourth or three-eights of an inch in diameter. Having provided a rest as near to the revolving stone as practical, the rod may be presented nearly perpendicular to its face. By inclining the rod slightly toward the part which is uncut, and rolling it gradually in the same direction while being held firmly, the stone will be reduced by a cutting edge, or rather nearly a point, which has a breadth of only about half the diameter of the rod in contact with the stone. A similar manipulation may be adopted with any very gritty material.

University of Michigan, July, 1868.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

The following rules and data in connection with belts for driving machinery, form part of a collection made by the writer for his own private use, and are here given as a condensed exhibit of the results derived from practical mechanical sources in the more accessible engineering publications, and from machinery now in operation in this city.

The deduction of a simple rule, from the statements given, which shall serve the needs of all cases in practice, may neither be fair nor easy, yet it is believed that a relation exists between the quantity, or properly the *area* of belt in motion and the power transmitted thereby, when under certain conditions, which might be expressed in simple terms, and answer the wants of usual practice. The reader can best judge for himself as to the existence of such a relation in a perusal of the facts which follow.

1. The width of a certain belt is 18 inches, speed of same 1500 feet per minute, angle of belt with horizon 45°, distance between centres of drums 25 feet, diameter of driving drum 8 feet, of driven drum 4 feet.

When this belt transmitted 20 horse-power, it worked quite freely and well, when the power was increased to 28 horse, a tightener had to be applied, which caused the journals of the driven shaft to "heat."

From the above data we deduce the following formula:

$$\frac{\text{H P} \times 3\frac{3}{5}}{\text{Diam. small pulley in feet}} = \text{width of belt in inches.}$$

If we consider this belt as transmitting $22\frac{1}{2}$ horse-power, we shall have a constant travel of 100 square feet of belt per minute per horse-power, assuming the above conditions.—*Appleton's Dict. of Mech.*

2. "An 8-inch belt, running 100 feet per minute, will give one horse-power." This rule is equivalent to the transmission of $66\frac{2}{3}$ square feet of belt per minute per horse-power.

3. An old rule provides 100 square feet of belt per minute for every horse-power, and we have heard it remarked that half that amount was sufficient.

4. "A 12-inch belt, running on a 5½-foot pulley, making 45 revolutions per minute, will carry away 12 horse-power." This rule gives 64·8 square feet of belt per minute per horse-power.

5. A friend gave me the following:

$$W = \frac{350 \text{ horse-power}}{D \times \text{rev. per minute.}}$$

In which W = width of belt in inches.

D = diameter of pulley in feet.

This gives a strain of 30 pounds per inch of width of belt and 91·63 square feet of belt transmitted per horse-power per minute.

6. "A certain 11-inch belt daily transmits from a 4 feet pulley, running 60 revolutions per minute, the power exerted by an 11-inch cylinder, 30-inch stroke, making 45 revolutions per minute under 50 pounds of steam, which, at the usual method of rating, yields 29 horse-power. This belt runs vertically without an idler, and measures 23·8 square feet per minute per horse-power."—*Sci. Amer.*, July, 1865, page 4.

7. "An empirical rule for ascertaining the width of belts that we know to be in use by some good practical men is as follows:"

$$B = \frac{31{\cdot}4\ N}{n\,d}.$$

In which B = width of belt, thickness taken at $\frac{3}{16}$-inch.

N = No. horse-power.

n = No. revolutions per minute.

d = diameter of pulley.—*Lond. Mech. Mag.*, Mar., 1863.

8. "Our engine is a 16-inch cylinder, 24 inches stroke, running 75 revolutions per minute under 80 pounds of steam. Belt 15 inches wide, on driving pulley 8 feet diameter, driven pulley 3 feet higher than the engine shaft, and 24 feet distant, top belt 'slack,' no tightener used and belt never slips."

"We drive with this belt 3 'runs' of stone with all the necessary machinery. Engine is rated at 60 horse-power."—W. R. C. in *Sci. Amer.*, July, 1865, page 36.

This is 39·27 square feet of belt per minute per horse-power at the above rating.

9. "I lately put up a belt 12 inches wide, having a velocity of 800 feet per minute for driving a pair of 54-inch wheat buhrs, 140 turns per minute. I calculate the power at 12 horse. The belt works beautifully. This belt had a tightener pressure of 400 pounds, and runs horizontal."

"We used to put 10-inch belts on 8-foot fly-wheels, of engines which we sold for 12 horse-power, running the belts at 1000 feet per minute."—J. W. H. in *Sci. Amer.*, July, 1865, page 53.

These examples give 66⅔ and 69·44 square feet per minute per horse-power, respectively.

10. "At a speed of 1800 feet per minute on pulleys over 36 inches diameter, every 1 inch wide will give 2 horse-power."

This equals 75 square feet per minute per horse-power.

11. "The old rule is 1 inch wide to the horse-power at 1500 feet per minute," which is 125 square feet per minute per horse-power.

12. A certain 6-inch × 12-inch cylinder horizontal engine, with plain slide valve, arranged to cut off at ⅝ths the stroke, works under 80 pounds of steam, has a 7-inch belt on a 4-foot pulley on engine shaft making 100 revolutions per minute, and drives a 30-inch pulley on the "line" shaft about 4 feet above the cylinder.

A 24-inch pulley on the other end of this "line," carrying a 7-inch belt, with a "half-twist," drove a 10-inch pulley on a shaft about 18 feet beneath the former.

The 10-inch pulley shaft, in its turn, drove a certain machine which consumed more power than the engine was capable of giving.

The result was, the 7-inch belt from the line to the 10-inch pulley, would continue to slip even when very tight and well covered with resin, while the 7-inch belt from the line to the pulley on the engine shaft would hold firmly to its pulleys and stop the engine.—*Writer.*

13. In hoisting the materials for the towers of the Cincinnati Bridge, Mr. John A. Roebling, Esq., used engines of 10 inches bore and 20 inches stroke, making 80 to 150 revolutions per minute, and working under a steam pressure, ranging from 60 to 80 pounds.

The power of these engines is transmitted by a 9-inch leather belt, from a 4-foot iron pulley on the engine shaft, to another 4-foot pulley on the pinion shaft. This pinion is 14½ inches diameter, and drives a 6-foot spur-wheel, on the shaft of this latter is another 14½-inch pinion, gearing into another 6-foot spur-wheel on the shaft of which is secured a 3-foot drum. This drum carries a 1½ inch diameter wire rope connected directly to the loads to be lifted.

A block, weighing 8400 pounds, can be raised at the rate of 50 feet per minute, by pressing the tightener down so that the belt laps on ⅜ths of the circumference of the 4-foot pulleys.

With a load of 10,200 pounds the belt slips, and its splicings and

safety are endangered by too severe an application of the tightener which is necessary to lift this weight. A load of 8000 pounds may therefore be considered a fair working condition of the belt, which indeed it has endured nearly three seasons without failing.

Blocks weighing 8000 pounds have been frequently raised 150 feet high in two and a half minutes, without slippage of the belt. This speed is equal to 60 feet per minute, and the duty performed is equivalent to $60 \times 8000 = 480{,}000$ pounds $= 14{\cdot}54$ horse-power, speed of belt being 1885 feet per minute.

Quantity of belt running per minute, per horse-power $= 97{\cdot}232$ square feet.—J. A. R. in *Sci. Amer.*, July, 1865, page 68.

14. From Molesworth's *Pocket-Book of Engineering Memoranda*, we take the following:

V = velocity of belt in feet per minute.

H P = horse-power (actual) transmitted by belt.

$$X = \frac{33{,}000 \text{ H P}}{V}.$$

S = strain on belt in pounds.

W = width of single belting ($\frac{3}{16}$ inch thick) in inches.

$$S = x + \frac{X}{K}.$$

$$W = \frac{S}{50}.$$

K = ·09, 1·3 and 1·6 when portion of driven pulley embraced by belt = ·40, ·50 and ·60 of the circumference, respectively.

For double belting the width = W × 0·6.

Approximate rule for single belting $\frac{3}{16}$ inch thick,

$$(a.) \ldots W = \frac{1100 \text{ H P}}{V} = 91\tfrac{2}{3} \text{ per square feet per minute}$$

per horse-power.

"The formulæ above apply to ordinary cases, but are inapplicable to cases in which very small pulleys are driven at very high velocities, as in some wood cutting machines, fans, &c. The acting area of the belt on the circumference of the driven pulley being so small that either great tension or a greater breadth than that determined by the formula is required to prevent the belt from slipping."

(To be continued.)

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 119).

10. *Attraction,* 11. *Repulsion.*

Attraction exists between the minute parts or *atoms* of bodies, and they would continually approach, until contact supervened, if they were not kept apart by an equal and opposing repulsion. These molecular attractions and repulsions are often designated as *the molecular forces.*

The phenomena of traction, of compression, of porosity, and of the transmission of vibrations through all kind of matter, prove indirectly that bodies are formed of minute parts which do not touch, but are kept at certain distances depending on the intensity of the attractions and repulsions subsisting between them; while there are many direct proofs of the above statement which will be given further on.

All *masses* of matter mutually attract each other with an intensity directly proportional to their masses, and inversely as the squares of their distances. This tendency is called *gravitation,* and is common to all matter. This is shown in the celebrated experiment devised by the Rev. John Michell, and generally known as the Cavendish experiment for determining the density of the earth. Describe this apparatus.

Electric and magnetic attractions and repulsions also follow the law of the inverse squares of the distances.

The different manifestations of attraction and repulsion may be thus arranged:

GRAVITATION, ELECTRICITY, MAGNETISM,	Which act at sensible distances; *i. e.* beyond the $\frac{1}{2000}$th of an inch,
COHESION, ADHESION, CAPILLARITY, CHEMICAL AFFINITY,	Which act at insensible distances; *i. e.* within the $\frac{1}{2000}$th of an inch.

Molecular Attraction.

Cohesion designates the attraction existing between the minute parts of the same body; *adhesion* the attraction between the parts of dissimilar bodies. Sometimes designated respectively as homogeneous and heterogeneous attraction.

Experiments on *Cohesion of solids.*—Two leaden planes pressed together, cohere with a force of forty pounds to the square inch. Two plates of glass cohere even in vacuo, which shows that the phenomenon is not due to the atmospheric pressure. The intensity of the cohesion in this experiment is proportional to the surface, and increases with the time of contact. In plate glass manufactories, mirror glasses sometimes cohere with such force, from having been placed on each other without intervening paper, that it is impossible to separate them. It is to be remarked that in the above instances only a comparatively few points of the cohering surfaces are in contact.

"There is a precious experiment by Mr. Huyghens in No. 86 of the Philosophical Transactions. A piece of mirror glass being laid on the table, and another, to which a handle was cemented on one surface, being gently pressed on it, with a little of a sliding motion, the two adhered, and the one lifted the other. Lest this should have been produced by the pressure of the atmosphere, Mr. Huyghens repeated the experiment in an exhausted receiver, with the same success.

"He found that one plate carried the other, although they were not in mathematical contact, but had a very sensible distance between them. He found this by wrapping round one of the plates a single fibre of silk drawn off from the cocoon. The adhesion was vastly weaker than before, but still sufficient for carrying the lower plate.

"Here, then, is a most evident and and incontrovertible example of a mutual attraction acting at a distance. Mr. Huyghens found that if, in wrapping the fibre round the glass, he made it cross a fibre already wrapped round it, there was no sensible attraction. In this case, the glasses were separated by a distance equal to twice the diameter of a fibre of silk.

"I said that this experiment showed that it was not the attraction of gravitation that produced the cohesion. I have repeated the experiment with the most scrupulous care, measuring the disance of the glasses (the diameter of a silk fibre), and the weight

supported. I find this, in all cases, to be nearly 14½ times the action of gravity. The calculation is obvious and easy. I tried it in distances considerably different, according to the diameter of the fibre. I must inform the person who would derive his information from his own experiments, that there are many circumstances to be attended to which are not obvious, and which materially affect the result. The silk fibres are not round, but very flat, one diameter being almost double of the other. The 2400th part of an inch may be considered as the average smaller diameter of a fibre. A magnifying glass must be used, and great patience in wrapping the fibre round the glass so that it may not be twisted. A flaxen fibre is much preferable, when gotten single, and fine enough, for it is a perfect cylinder. I must also inform him, that no regularity will be had in experiments with bits of ordinary mirror; these are neither flat enough, nor well enough polished. We must employ the square pieces which are made and finished by a *very few London artists* for the specula of the best Hadley's [Godfrey's] quadrants. These must be most carefully cleaned of all dust or damp. Yet this must not be done by wiping them with a clean cloth; this infallibly deranges everything by rendering the plate electric. I succeeded best by keeping them in a glass jar, in which a piece of moist cloth was lying, but not touching the glasses. When wanted, the glasses are taken out with a pair of tongs and held a little while before the fire, which dissipates the damp which had adhered to them, and which prevented all electricity. With these precautions, and a careful measurement of the diameter of the silk fibre, the experiments will rarely differ among themselves one part in ten.

"* * * * * * If the plates have been hard pressed, with a sliding or grinding motion, the adhesion is then either very strong, or nothing at all; when they do adhere, it seems to be another stage or alternation of the force, as will be explained by and by. But they rarely adhere, owing to fragments torn off by the grinding. The glasses will be scratched by it.

"I thought this capital experiment worthy of a very minute description, it being that which gives us the means of mathematical and dynamical treatment in the greatest perfection." "*A System of Mechanical Philosophy*, by John Robison, L. L. D. Edited by Sir David Brewster, Edinburg: printed for John Murray, London, 1822." Vol. I. page 240, *et seq.*

Cohesion in solids is measured by the force in pounds avoirdu-

pois required to tear apart, by a direct pull, a rod of one square inch area of section. This measure is called the *tenacity* of a body.

TABLE OF TENACITIES FROM "RANKINE'S APPLIED MECHANICS."

Steel	115,000
Iron, wire	95,000
" wire ropes	90,000
" wrought bars and bolts	65,000
" cast	16,500
Copper, wire	60,000
" cast	19,000
Brass, wire	49,000
" cast	18,000
Gun-metal (copper 8, tin 1)	36,000
Zinc	7,500
Tin, cast	4,600
Lead, sheet	3,300
Teak	18,000
Ash	17,000
Mahogany	16,200
Locust	16,000
Oak, European	14,900
" American red	10,250
Fir—red pine	13,000
" spruce	12,400
" larch	9,500
Chestnut	12,000
Beech	11,500
Maple	10,600
Hempen cables	5,600
Slate	11,200
Glass	2,400
Brick	290
Mortar	50

Cohesion of liquids is shown in the force required to separate a disk of wood from a liquid which wets it; this force varies with the liquid, requiring 52 grains per square inch to separate the disk from water; 31 grains for oil of turpentine; 28 grains for alcohol. These experiments, however, as will be seen below, give only the *relative* cohesion.

Prof. Joseph Henry, in a valuable contribution to molecular physics, published in the *Proceedings of the American Philosophical Society* for April, 1844, showed that the molecular attraction of water for water, instead of being only about fifty-two grains to the square inch, is really several hundred pounds, and is

probably equal to that of the attraction of ice for ice. The following are extracts from Dr. Henry's paper:

"The passage of a body from a solid to a liquid state is generally attributed to the neutralization of the attraction of cohesion by the repulsion of the increased quantity of heat; the liquid being supposed to retain a small portion of its original attraction, which is shown by the force necessary to separate a surface of water from water, in the well known experiment of a plate suspended from a scale beam over a vessel of the liquid. It is, however, more in accordance with all the phenomena of cohesion to suppose, instead of the attraction of the liquid being neutralized by the heat, that the effect of this agent is merely to neutralize the polarity of the molecules so as to give them perfect freedom of motion around every imaginable axis. The small amount of cohesion (52 grains to the square inch), exhibited in the foregoing experiment, is due, according to the theory of capillarity of Young and Poisson, to the tension of the exterior film of the surface of water drawn up by the elevation of the plate. This film gives way first, and the strain is thrown on an inner film, which, in turn, is ruptured; and so on until the plate is entirely separated; the whole effect being similar to tearing the water apart atom by atom.

"Reflecting on the subject, the author has thought that a more correct idea of the magnitude of the molecular attraction might be obtained by studying the tenacity of a more viscid liquid than water. For this purpose, he had recourse to soap water, and attempted to measure the tenacity of this liquid by means of weighing the quantity of water which adhered to a bubble of this substance just before it burst, and by determining the thickness of the film from an observation of the color it exhibited in comparison with Newton's scale of thin plates. Although experiments of this kind could only furnish approximate results, yet they showed that the molecular attraction of water for water, instead of being only about 52 grains to the square inch, is really several hundred pounds, and is probably equal to that of the attraction of ice for ice. The effect of dissolving the soap in the water, is not, as might at first appear, to increase the molecular attraction, but to diminish the mobility of the molecules, and thus render the liquid more viscid.

"According to the theory of Young and Poisson, many of the phenomena of liquid cohesion, and all those of capillarity, are due to a contractile force existing at the free surface of the liquid, and

which tends in all cases to urge the liquid in the direction of the radius of curvature towards the centre, with a force inversely as this radius. [The explanation of the existence of this contractile force will be given in the next section of the Notes, which considers Capillarity.]

"According to this theory, the spherical form of a dew-drop is not the effect of the attraction of each molecule of the water on every other, as in the action of gravitation in producing the globular form of the planets (since the attraction of cohesion only extends to an appreciable distance), but it is due to the contractile force which tends constantly to enclose the given quantity of water within the smallest surface, namely, that of a sphere. The author finds a contractile force similar to that assumed by this theory, in the surface of the soap-bubble; indeed, the bubble may be considered a drop of water with the internal liquid removed, and its place supplied by air. The spherical form in the two cases is produced by the operations of the same cause. The contractile force in the surface of the bubble is easily shown by blowing a large bubble on the end of a wide tube, say an inch in diameter; as soon as the mouth is removed, the bubble will be seen to diminish rapidly, and at the same time quite a forcible current of air will be blown through the tube against the face. This effect is not due to the ascent of the heated air from the lungs, with which the bubble was inflated, for the same effect is produced by inflating with cold air, and also when the bubble is held perpendicularly above the face, so that the current is downwards.

"Many experiments were made to determine the amount of this force, by blowing a bubble on the larger end of a glass tube in the form of a letter U, and partially filled with water; the contractile force of the bubble, transmitted through the enclosed air, forced down the water in the larger leg of the tube, and caused it to rise in the smaller. The difference of level observed by means of a microscope, gave the force in grains per square inch, derived from the known pressure of a given height of water. The thickness of the film of soap-water which formed the envelope of the bubble, was estimated as before, by the color exhibited just before bursting. The results of these experiments agree with those of weighing the bubble, in giving a great intensity to the molecular attraction of the liquid; equal at least to several hundred pounds to the square inch. Several other methods were employed to measure the

tenacity of the film, the general results of which were the same; the numerical details of these are reserved, however, until the experiments can be repeated with a more delicate balance.

"The comparative cohesion of pure water and soap-water was determined by the weight necessary to detach the same plate from each; and in all cases the pure water was found to exhibit nearly double the tenacity of the soap-water. The want of permanency in the bubble of pure water is therefore not due to feeble attraction, but to the perfect mobility of the molecules, which causes the equilibrium, as in the case of the arch, without friction of parts, to be destroyed by the slightest extraneous force."

The above investigation of Dr. Henry will be referred to again under the head of Capillarity.

Gases.—Between the molecules of the same gas repulsion exists, but a slight attraction appears to prevail between the molecules of different gases.

Adhesion.—Of solids to solids.—Plating of metals. Gold leaf stamped on metals. "It is known that if two pieces of metal are *scraped* very clean, a severe blow will make them to cohere so as to be inseparable. It is thus that flowers of gold and silver are fixed on steel and other metals. The steel is first scraped clean, and a thin bit of gold or silver is laid on it, and then the die is applied by a strong blow with a hammer. It is remarkable that they will not adhere with such firmness, if they adhere at all, when the surfaces have been polished in the usual way, with fine powders, &c. This is always done with the help of greasy matters. Some of this probably remains, and prevents that *specific* action that is necessary. I am disposed to think that the scraping of the surfaces also operates in another way, viz: by filling the surface with scratches, that is, ridges and furrows. These allow the air to escape as the pieces come together by the blow. If the mere blow were sufficient, a coin would adhere fast to the die. But, in coining, the flat face of the die first closes with the piece of metal, and effectually confines the air which fills the hollow that is to form the relief of the coin. This air must be compressed to a prodigious degree, and in this state, it is still between the die and the coin. We may say that the impression on the coin is really formed by this included air; for the metal in this part of the coin is never in contact with the die. I know of two cases, which greatly confirm this conjecture. The dies chanced to crack in the highest part of the relief, and after this were thrown aside (although in one, for a common die, the crack

was quite insignificant), because the coin could seldom be parted from them."—[*Robison.*]

When bladder is dried on glass, the adhesion is so great that it cannot be torn off without bringing with it some of the glass.

Of solids to liquids.—A rapidly issuing jet of water is deflected from its course by touching a glass rod.—Experiments quoted above, on relative cohesion.

Of liquids to liquids.—Oil and spirits of turpentine spread over the surface of water.

Of gases to solids.—Air and vapor of water adhere with considerable force to the surface of glass. This shown by placing a beaker of water under the receiver of an air pump, when bubbles of air, previously coating as a film the surface of the glass, collect on its surface. That vapor of water also coats with a film the glass, is known from the increase in weight of a dry light glass vessel, when exposed to a damp atmosphere.—The action of clean platinum and gold in condensing gases on their surfaces.—Charcoal absorbs 98 times its volume of ammonia, and 14 volumes of carbonic acid gas. As ammonia is condensed into a liquid by a pressure of seven atmospheres, at a temperature of 60° F., it follows that the absorbed gas must exist in the liquid state in the interstices of the charcoal. Gold leaf will not sink in water from the air condensed on its surface.

Of gases to liquids.—Air and all gas absorbed by water. Oxygen gas absorbed from the air by melted silver.

Of gases to gases.—In the diffusion of gases, one gas acts as a vacuum to another. Vapor diffuses in space containing a gas, until the same tension is produced as would have been acquired by the same vapor evaporating from its liquid in a vacuum.

Molecular Repulsion.

When the convex surface of a plano-convex lens, of a radius of curvature of 20 feet or more, is pressed upon a plate of glass, a system of concentric colored rings are observed. These rings are produced by the interference of certain of the rays of light reflected from the under surface of the lens with those reflected from the upper surface of the glass plate. By knowing the diameter of any ring, and the radius of curvature of the lens, we can calculate the distance between the convex surface and the glass plate corresponding to the ring. Newton thus found that the distance at each ring exceeded the distance of the ring immediately within it by the $\frac{1}{89000}$th of an inch.

Now, unless the lens be heavy, or pressed against the glass plate, no colored spot appears in the centre, and it can be shown that the glasses are, in this case, not in contact, but distant from each other at least $\frac{1}{4450}$th of an inch, and at this distance reposes the upper glass, kept from the plate by a *repulsion* existing between them.

By forcing the glasses nearer together, we at length produce a *black* spot at the centre of the ring system, and Prof. Robison found that "a very considerable force is necessary for producing the black spot. A greater pressure makes it broader, and in all probability this is partly by the mutual yielding of the glasses. I found that before a spot, whose surface is a square inch, can be produced, a force exceeding 1,000 pounds must be employed. When the experiment is made with thin glasses, they are often broken before any black spot is produced.

"What is it that we properly, and without any figure of speech, call a pressure? It is something that we are informed of solely by our sense of touch. What do we feel by means of this sense, when the upper lens lies in our hand? It is not the matter of this lens, for we now see that there is some measurable distance between the lens and the hand; it is this repulsion. Give a blind man a strong magnet in his hand, and let another person approach the north pole of a similar magnet to its north pole. The blind man will think that the other has pushed away the magnet he holds in his hand with something that is soft.

* * * * * * * *

"There is, therefore, an essential difference between *mathematical and physical contact;* between the absolute annihilation of distance and the actual pressure of adjoining bodies. We must grant that two pieces of glass are not in mathematical contact till they are exerting a mutual pressure not less than 1,000 pounds per inch. For we must not conclude that they are in contact till the black spot appears; and even then we dare not positively affirm it. My own decided opinion is, that the glasses not only are not in mathematical contact in the black spot, but the distance between them is vastly greater than the 89,000th part of an inch, the difference of the distances at two successive rings.

* * * * * * * *

"While gravity produces sensible effects at the utmost boundary of the solar system, these [attractions and repulsions] seem limited in their exertion to a small fraction of an inch, perhaps not exceed-

ing $\frac{1}{2000}$th part in any instance; and in this narrow bounds we observe great diversity in the intensity, although we have not yet been able to ascertain the law of variation. What is of peculiar moment, we have seen that those corpuscular forces even change their kind by a change of distance, producing at one distance, the mutual approach, and at another distance the mutual separation of the acting corpuscles, from being attractive, becoming repulsive.

* * * * * * * *

"Physical contact, or *pressure*, becomes *sensible* at the distance of the 5000th part of an inch nearly, and decreases much faster than in the inverse duplicate ratio of the distances. I could infer this from my experiments with the glasses with great confidence, although I could not assign the precise law." *Robison's Mechanical Philosophy*, Vol I. p. 250, *et seq.*

All bodies expand when relieved of pressure, and this expansion is caused by the mutual repulsion of their atoms.

A dew drop does not touch the leaf above which it reposes, but is held at a certain distance by repulsion. Certain insects walk on water, which is repelled by their feet, so that each foot rests in a pit. A needle floats on the surface of water, in which it forms a trough in which it rests.

Prof. Baden Powell has shown (*Phil. Trans.* 1884, p. 485), that the colored rings known as Newton's rings, change their breadth and position in such a manner, when the glasses which produce them are heated, that he inferred that the glasses repelled each other.

"The *distance* at which the repulsive power can act, is shown by these experiments to extend beyond that at which the most extreme visible order of Newton's tints is formed. But I have also repeated the experiment successfully with the colors formed under the base of a prism placed upon a lens of a very small convexity; and according to the analysis of these colors given by Sir John Herschel, the distance is here about the 1100th of an inch."

Very finely divided solids, such as elutriated silica and wood-ashes will, when rendered incandescent, flow like liquids about the capsule which contains them; while it can be directly shown that a sensible distance exists between a layer of these powders and a heated plate on which it rests.

(To be continued.)

A NEW FORM OF WAVE APPARATUS.

By Prof. C. S. Lyman.

[We find in a late number of *Silliman's Journal* a full description of the above, which is undoubtedly the most admirable piece of mechanism for the illustration of inter-molecular motions (such as those concerned in the propagation of waves), that has ever been devised. The beauty and admirable completeness as an illustration, of this apparatus, can only be appreciated by actual inspection of its operation. No description can convey an idea of the manner in which is revealed the complex, flexible, and yet regular motions of the interior particles of the fluid among themselves.—Ed.]

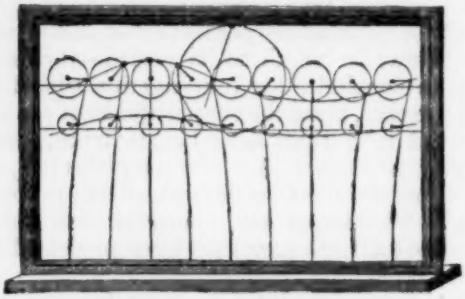
The theory of waves that has been generally taught since the days of Newton, is that which represents wave motion as consisting in the alternate rising and falling of the parts of a liquid in vertical lines, as in the two branches of a U-shaped tube; this is usually cited as Newton's theory of waves. There is to be found, indeed, in the *Principia*, the hypothesis of vertical oscillations, and also the cut of the bent tube, so persistently copied by subsequent writers; yet it is evident that Newton adopted the hypothesis, rather as an expedient for a special purpose—that of finding approximately the relation of a wave's length to its period—than as strictly true to nature; for he concludes his investigation with the remark:—"These things are true, upon the supposition that the parts of water ascend or descend in a right line; but, in truth, that ascent and descent is rather *performed in a circle* ('*verius fit per circulum*'); and therefore I propose the time defined by this proposition as only near the truth." This important qualifying clause seems to have been quite overlooked by those who have professed to give Newton's theory of waves.

The modern theory—which teaches that, in wave motion, all the particles of a liquid are revolving synchronously in vertical circles—though so broadly hinted at by Newton himself as the true one, in the words italicised above, has nevertheless been developed, for the most part, only within the present century. It was first clearly stated and ably advocated by Gerstner in 1804. More recently, it has been satisfactorily established as accordant with observed facts and the laws of Mechanics, by the experimental researches of Weber and Scott Russell, and the mathematical investigations of Stokes, Rankine, and others. A concise exposition and demonstration of the theory may be found in a paper by Prof. Rankine, in the Philosophical Transactions for 1863. Though but just beginning to find its way sparingly into the text books, it has become the generally accepted theory among men of science; and having in reality supplanted the old hypothesis as an expression of scientific truth, there

is no good reason why it should not also supplant it, in the lecture and recitation room.

In teaching this theory, however, it is often found difficult to make pupils understand, how the infinitude of simultaneous revolutions which it supposes can take place without mutual interference, and in such a way as to produce the observed phenomena. It was to obviate this difficulty, and illustrate, as far as practicable, the *modus operandi* in question, that the piece of mechanism was devised, which is the subject of this article. It presents to the eye not merely the surface contour of a wave, with its undulatory motion—which, to some extent, other forms of wave apparatus also do—but, besides doing this in a more exact and satisfactory manner, it exhibits the motions also that are at the same time taking place below the surface, in the whole mass of liquid affected. This completeness of illustration is due to the circumstance, that in the apparatus, the elementary motions are the same, essentially, as in actual waves; hence, the leading points, geometrical and dynamical, of the theory of waves, are presented naturally, and in their true relations.

The construction of the apparatus will be readily understood from a brief description, and the accompanying cut.



In front of a plane surface are two series of revolving arms or cranks, the length of the lower ones being half that of the upper. Two elastic wires connect the crank-pins of each series; upright wires also connect each pair of cranks, and pass down through a plate into the base. The cranks all revolve synchronously; they thus keep their relative position, and come into any given position successively, each in its turn. The relative position of the cranks of each horizontal series is such, that the directions of any two, in regular order, differ by the same fraction of a whole revolution, that the distance between their axes is of a whole wave length. Thus, in the apparatus, the wave length is supposed to be divided into eight equal parts, and hence the common difference between the directions of adjacent crank arms is one-eighth of a circle, as shown in the figure. The cranks in each vertical set have their

positions always alike. The number of cranks, whether taken horizontally or vertically, is arbitrary—a matter of convenience in construction. The synchronous revolution of the cranks is effected by means of any suitable mechanism; such as equal toothed wheels on the several axes, with alternate idle wheels connecting them; or, equal rag-wheels, with endless chain, or metallic ribbon; or, equal cranks, with a rigid connecting frame or plate. The first method is used in the original machine, the third in the model for the Patent Office, the second and third in the larger and smaller sizes, respectively, for the market.

The crank-pins represent as many liquid particles; the circles on the background their orbits. The transverse wires represent continuous lines of particles, which at rest would be horizontal, and be represented by the lines on the background drawn just below the centres of the orbits; the upper one of these being the surface line, the lower a line of particles one-ninth of a wave's length down. The upright wires represent lines of particles which at rest would be vertical. Every point in these moving lines describes its own distinct orbit.

The apparatus is constructed to a scale; and so, represents a wave of given length, height and period; but equally represents also, a wave of any other length and proportionate height, though of period proper to its length, according to the law of that relation, as stated farther on. In the original instrument, for example, the wave length it 36 inches; height, from trough to crest, 4 inches; and period, for that length, 0″·76; but it equally represents a wave whose length is 36 feet and height 4 feet, with period 2″·63; and similarly, for other proportional dimensions.

Among the particular points, in wave phenomena, which are elucidated by this apparatus, may be enumerated the following:

1. *The undulating surface-profile.* This is shown in the motion of the upper flexible wire, which presents a continuous contour line, of the exact curvature, throughout, of a true normal wave; instead of a broken contour, of arbitrary form, by means of rising and falling balls, as in the ordinary wave apparatus.

2. *The undulatory motion of all sub-profiles, or lines of equal pressure, down to still water.* The representative of such lines is the lower transverse wire, which moves similarly to the upper one, but with a less curvature. Every such line of equal pressure is a continuous one, composed of particles in a state of dynamical equilibrium, and constituting an ideal moving wave, exactly as if at the surface —the corresponding phases of all such waves being on vertical lines.

3. *The genesis of the undulatory motion from the circular motion of revolution.* This is seen in the mode in which the crank-pins, in each transverse series, or the particles which they represent, come in regular succession into a given position, as they revolve synchronously in their orbits.

4. *The equality of the height of a wave, from trough to crest, with the diameter of the orbits of the surface particles.* This is obvious in the apparatus, and follows directly from the mode in which the wave surface is generated.

5. *The direction of motion of particles of water in the different phases of a wave.* A glance at the motion of the crank-pins, shows that a particle at the wave's crest is moving forward, or in the direction in which the wave is propagated, and a particle at the trough in the reverse direction, or backward; that a particle on the forward slope is rising, and one on the back slope descending. The same is true of particles in all the sub-waves, or surfaces of equal pressure, down to still water.

6. *The length of a pendulum keeping time with the wave.* This is equal to the radius of a circle whose circumference is the wave's length. Such a circle is the large one drawn on the back-ground, as shown in the figure. Its radius is to that of a particle's orbit (or length of a crank-arm), as the particle's weight is to its centrifugal force. Or, putting R and r for these radii respectively, and t for the time of revolution, we make

$$R : r :: g : \frac{4\pi^2 r}{t^2};$$

Whence

$$t = 2\pi\sqrt{\frac{R}{g}};$$

which is the period of a revolving pendulum, or the time of a double oscillation of a simple pendulum, whose height is R. Compare (10).

7. *The dependence of a wave's period on its length alone—not on its height.* This is a corollary from the preceding. The period varies as the square root of the length, and is the same for all sub-waves, as for the surface-wave—the length being the same for all. The height, within certain limits, is independent of the length, as appears in the apparatus, and as may be inferred from the formulæ given farther on. It depends on the centrifugal force of the particle, and this, ultimately, on the external forces generating it.

8. *The varying direction and intensity of the resultant force acting at each instant on a given particle in a wave.* The component forces are two—the particle's gravity, and its centrifugal force. The former is represented by the vertical radius of the large circle, the latter by the radius vector of the revolving particle; their resultant, then, is represented by the third side of the triangle of forces, or the side formed by the wire pendulum. This resultant must be always normal to the wave surface, as the wire pendulum is seen to be always at right angles to the elastic wire representing that surface.

9. *The condition of a wave's rupture at the crest.* When the centrifugal force becomes equal to gravity (or the radius of the orbit to that of the large circle), the resultant force, for a particle at the highest point of its orbit, or crest of the wave, must be zero, and

the particle consequently fly from its orbit, or the crest break in foam.

10. *The trochoidal form of the wave curve.* The point of suspension of the pendulum, that is, the upper extremity of the vertical radius of the large circle, may be regarded as the instantaneous centre about which an element of the wave curve at the point of normalcy of the pendulum is described. Consequently, if this circle be rolled under a horizontal straight line, a point within it distant half the weight of a wave from the centre, will trace the wave profile; which, therefore, is a trochoid. The rolling circle is the same for all wave profiles, down to still water, the lengths of the tracing arm only differing. The circumference of this circle equals, of course, the wave's length.

11. *The greater sharpness of the crests than of the troughs of waves.* This follows from the preceding, and is shown in the relative positions of the crank-pins—nearer together at the crests, farther apart in the troughs. The trochoids become, necessarily, sharper at the upper bend, and less so at the lower, as the tracing arm approaches to an equality with the radius of the rolling circle; until, when that equality occurs, the trochoid passes into the cycloid, which has sharp cusps. The cusp of the inverted cycloid, then, is the limit of sharpness of a wave's crest. The quality above named is equivalent to that of the centrifugal force of a particle with its gravity (9). When the latter condition occurs, the wave curve is cycloidal, and only then.

12. *The limits of possible curvature of waves.* That curvature must always lie between the cycloid at the one extreme, and the straight line at the other—embracing trochoids of every possible variety.

13. *The greater elevation of the crests above the level of still water, than depression of the troughs below it.* The difference between this elevation and depression is equal to twice the height due to the orbital velocity of the particles, that is, to twice the height from which a body must fall to acquire that velocity; or, is a third proportional to the radius of the rolling circle and that of the particle's orbit; that is, putting R and r for these radii respectively, v for the orbital velocity, $\left(=\frac{2\pi r}{t}\right)$, and D for the difference in question,

$$D=\frac{r^2}{R}=\frac{v^2}{g}.$$

When r equals R, then D=r, or half the height of the wave.

14. *The elevation of the centres of the orbits of particles above the positions of the same particles at rest.* This is shown in the distance of the axes above the corresponding lines on the background. These lines show the positions of lines of particles at rest, which, in motion, form the wave profiles represented by the transverse wires.

The elevation in question is equal to the height due to the particle's orbital velocity; or, is a third proportional to the diameter of the rolling circle and the radius of the orbit; or, is equal to the area of the orbit divided by the length of the wave; that is, putting H for this elevation, l for the wave's length, and the other symbols as before,

$$H = \frac{r^2}{2R} = \frac{v^2}{2g} = \frac{\pi r^2}{l}.$$

When r equals R, $H = \frac{r}{2}$, or one-fourth the height of the wave.

To this elevation is due one-half the mechanical energy of a wave —the other half to the motion of its particles. That energy is, in other words, half potential, half actual.

15. *The decreasing diameter of the orbits with depth.* This is seen in the shorter crank-arms below, and the decreasing amplitude of sway of the upright elastic wires, down to their points of rest, which mark the depth of still water. The decrease of the orbits in diameter takes place in a geometrical ratio, and is approximately one-half for each increase of depth equal to one-ninth of a wave-length; or, more exactly, putting r and r' for the radii, respectively, of a surface orbit and of one whose middle depth is k, it is $r, = re^{-\frac{k}{R}}$, R being, as before, the radius of the rolling circle, and e the base of the Naperian logarithms.

16. *The peculiar swaying motion of continuous lines of particles of equal pressure, which at rest are vertical.* These lines are alternately lengthened and shortened, and bent to right and left, as represented by the upright elastic wires.

17. *The varying distortions undergone by blocks or sections of water originally rectangular, or rectangular when at rest.* Such sections are represented by the spaces between the wires, and their distortions by the distortions of these spaces.

18. *The fact of sensibly still water at half a wave's length below the surface.* This is exhibited in the absence of lateral motion at the lower extremities of the upright wires, and is a necessary result of the law of diminution of orbits with depth, as given above (13).

19. *The varying strain, in wave action, on floating bodies.* This is seen in the varying angle made by the upright wires with the upper transverse wire; the latter shows the position of a raft, for example, lying on the wave surface; the former, that of a long, thin body, as a board, floating end down; hence, the varying relative direction of the wires shows the strain to which a body is subjected, having both breadth and depth, as the hull of a vessel.

Many other points besides the above, may be studied to advantage in connection with this apparatus, but it is not important to specify them here. Enough have been stated to illustrate its utility,

and indicate in what respects it differs from every other form of wave apparatus.

For convenience of reference, and for the sake of completeness, a few formulæ are added, expressing other relations among wave phenomena, not so directly exhibited by the instrument, but important to be presented in connection with it. Putting V for the velocity of propagation of a wave, and the other symbols as before, the length of the wave is

$$l = 2\pi R = \frac{gt^2}{2\pi} = \frac{2\pi V^2}{g} = tV;$$

its period

$$t = \sqrt{\frac{2\pi l}{g}} = 2\pi\sqrt{\frac{R}{g}} = \frac{l}{V};$$

the velocity of a particle in its orbit; or at the crest of the wave,

$$v = \frac{2\pi r}{t} = r\sqrt{\frac{g}{R}} = r\sqrt{\frac{2\pi g}{l}} = \frac{Vr}{R} = \frac{2\pi rV}{l} = \frac{gr}{V} = \frac{tgr}{l};$$

the velocity of propagation of the wave

$$V = \frac{l}{t} = \frac{gt}{2\pi} = \sqrt{\frac{gl}{2\pi}} = \sqrt{gR} = \frac{gr}{v}.$$

the sine of the angle of steepest slope of surface is

$$\sin\theta = \frac{2\pi r}{l} = \frac{r}{R};$$

It will be understood that the normal wave, to which the theory applies, and which the apparatus illustrates, is the wave on deep water, or water a wave's length, at least, in depth. In shallow water, the orbits are no longer circles, but ovals, or approximate ellipses, of less height than length, according to the degree of shallowness.

When waves pass from deep into shallow water, as toward a beach, they become gradually shorter, their total energy is imparted to a less and less mass of liquid, and the extent of the motion of the particles is proportionately increased. The crests also travel faster than the troughs; so that the front of each wave becomes by degrees steeper than the back, and at length curls forward and falls over, exhibiting the well known roll of surf. The formulæ for waves in deep water require modification, therefore, to adapt them to waves in shallow water, where depth of liquid and ellipticity of orbit enter as elements.

It has been necessary, in order properly to explain the apparatus and its uses, to give more fully the leading points of the theory of waves, than would be required, were the works containing it more generally accessible. For these points the papers of Prof.

Rankine have been chiefly consulted. It is hoped that this outline of the theory, thus incidentally given, will prove not unacceptable to such instructors as may not have at hand the original works; and that this new piece of apparatus may contribute somewhat toward imparting a clearer understanding of the phenomena of waves.

The apparatus has been patented, and is manufactured by Messrs. E. S. Ritchie & Son, the well known philosophical instrument makers, of Boston, Mass.

THE GIFFARD INJECTOR.

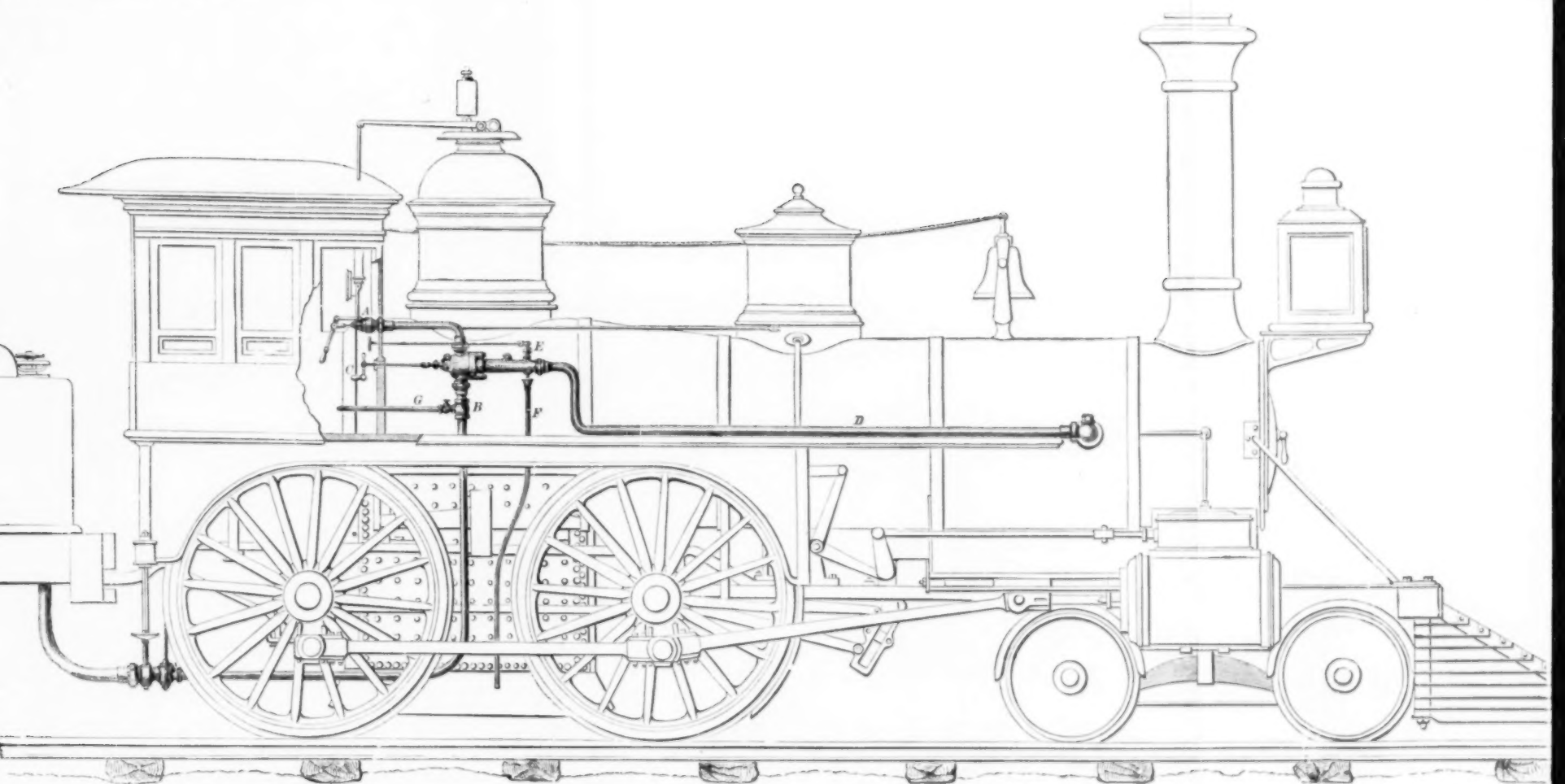
(Concluded from page 130.)

WE will now consider in the first place, the attachments needed when the injector is used upon a locomotive. The general arrangement of the instrument and its accessories will be readily understood from the accompanying Plate I., in which A represents the starting valve, B, the check-valve to the water supply, C, the regulating handle, D, the delivery pipe to the check-valve on the boiler, E, the escape or waste valve, F, the waste pipe, G, the alarm check and pipe to drip-pan, which is on the end of the boiler immediately in front of the engine-driver.

Among these attachments we will first select for description, the starting valve.

It will be readily perceived, from what has been already explained, that for the certain and successful operation of this injector, it should at first have a small supply of steam, in order to bring the water up into the nozzle, C, Fig. 4, and when this is accomplished, then a full supply, capable of carrying water into the boiler.

Even with the provisions of the interior passage in the plug, already described, with the high pressure often carried on locomotives, if the full head of steam was let on to the injector at first, it would prove too much for the outlet of C, while if the tube in the plug were made small enough to prevent this, it would then be too small to work with the low pressures which it is necessary sometimes to use. To meet this difficulty the starting valve, shown in Fig. 6, is used. In this case we have a double valve; that is, the stem C, fits by a conical face upon the valve, proper, D D; but when drawn back as far as the nut, E, will allow, steam can pass through the body of the large valve, by the small opening indicated in the drawing, and into the pipe E.



POSITION OF INJECTOR AND ACCESSORIES ON A LOCOMOTIVE.

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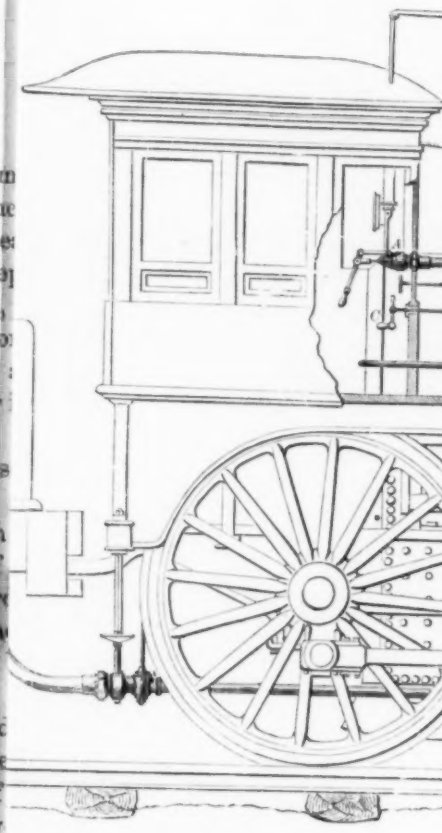

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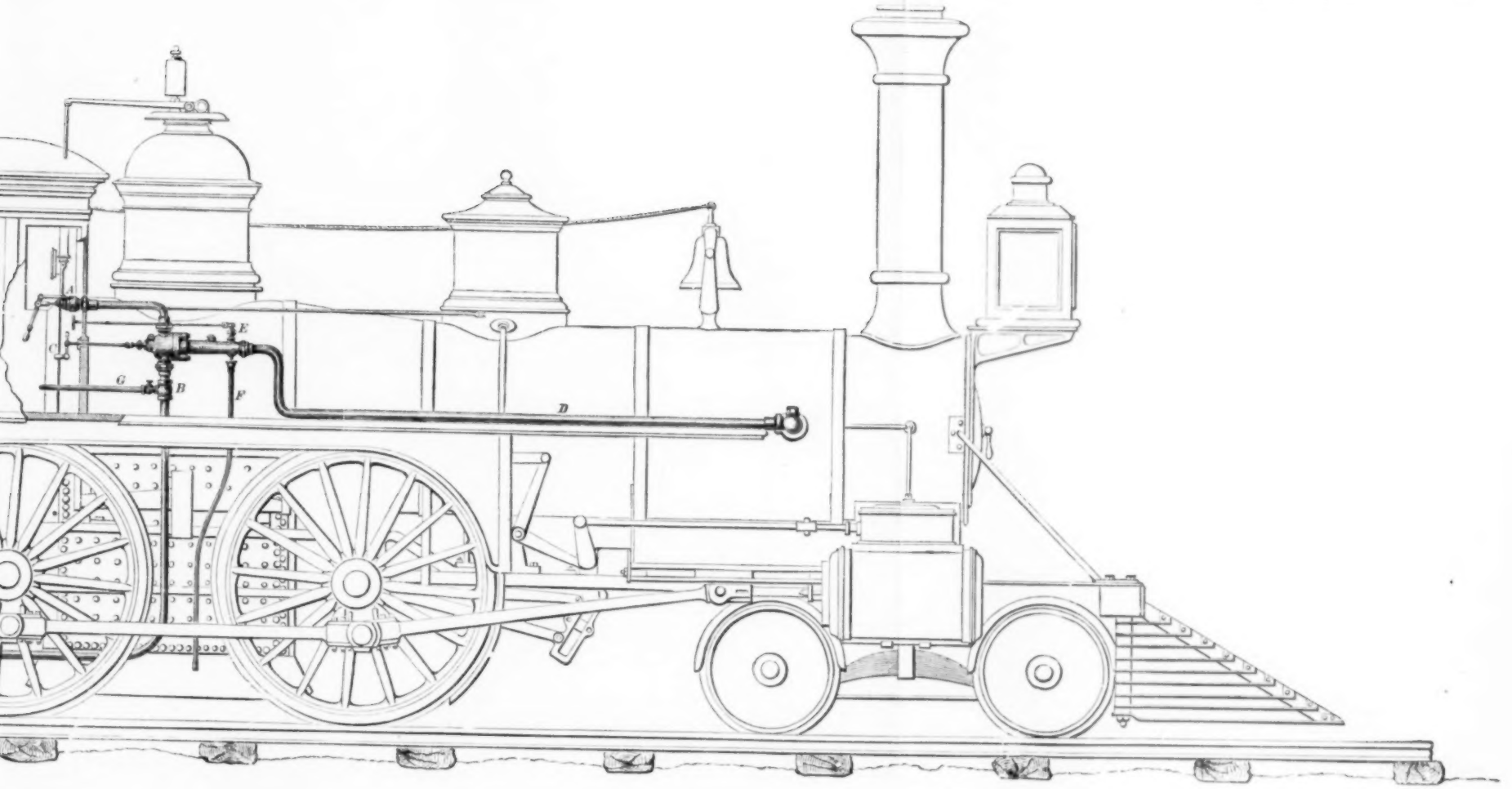
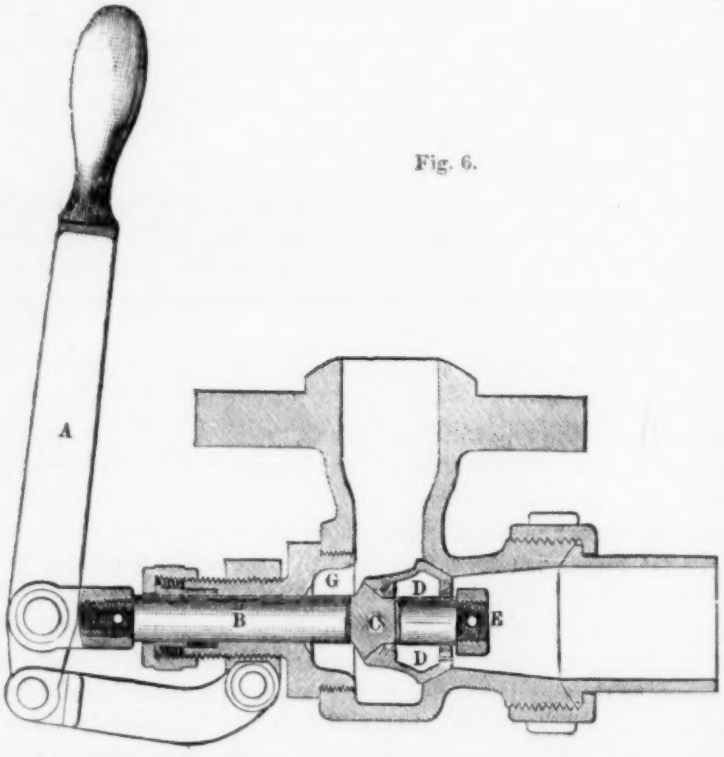


POSITION OF INJECTOR AND ACCESSORIES ON A LOCOMOTIVE.

It is found, in fact, very important that this opening should be very small, for it would otherwise be impossible to admit a sufficiently small amount of steam when a high presssure exists in the boiler. This can be well understood if we consider that under a pressure of say 90 lbs. to the square inch, the volume of the steam is reduced to one-sixth, and that thus a small orifice can deliver a quantity which will have a great volume when subsequently ex-

Fig. 6.



panded under an atmospheric pressure only. It might, perhaps, be supposed that a conical valve, like that shown at Fig. 4, operated by a fine threaded screw, would accomplish the same end. This is true as regards the gradual admission of steam at starting, but then, the time required to open the valve so as to give a full head of steam when required, would be excessive, and would occasion in practice great inconvenience. To open any ordinary valve, capable of admitting the maximum flow which would be required on some

occasions, with sufficient delicacy to start the injector with a high pressure of steam, would be impracticable, especially under the existing conditions of jar and motion in a locomotive.

The effect of this arrangement will be evident when we describe its operation.

Steam from the boiler filling the space, G, and pressing upon the valve, D D, keeps it firmly in its seat, so that when the handle, A, is pulled out with moderate force, the stem, B C, is alone moved, until the nut, E, is arrested against the face of the valve. The resistance offered by this valve will be very sensibly perceived, and will indicate when sufficient motion has been given to the handle.

Through the opening thus exposed by the interior valve, C, steam passes into the pipe, E, and to the injector, not only with sufficient rapidity to raise water for the action of that instrument but also in such quantity as to accumulate in the pipe, E, so as to balance, in part, the pressure on the valve, D D, and thus render it easy when the right time comes (which is after a few moments) to open this valve by a further motion of the handle, A, and admit a full head of steam to the injector.

Thus the necessities of the case are provided for in this respect.

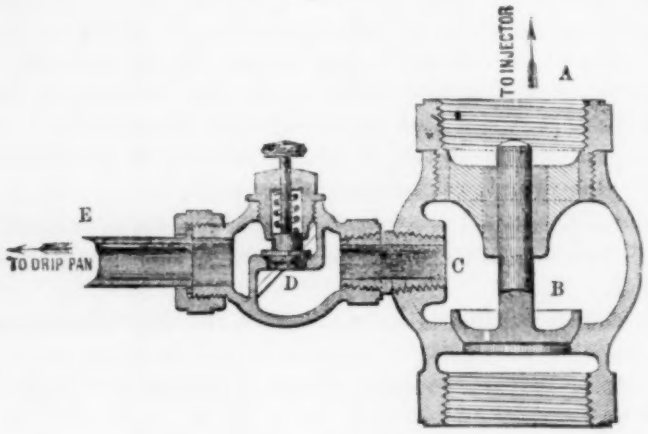
It is again of vital importance that the engineer should be notified whenever the injector, from any cause, either ceases to operate or fails to start. This is secured by means of the *alarm check valve*, which we will now describe.

If the injector is not working into the boiler when the escape valve, (P. Fig. 4,) is closed, it is clear that the steam will back up in C, and tend to pass out into the water supply and tank. As soon, however, as any pressure occurs in the upper part of the supply-pipe, the check-valve, B, Fig. 7, will close, and the steam then exerts its pressure on the small check, D, in the lateral pipe, C E, which leads to the drip pan. This small valve, which is kept in its seat by a spiral spring, as shown in the drawing, will then be raised, and allow the steam to escape into the drip pan in a way that cannot fail to secure notice.

In cold weather it is important to have some means of passing steam into the tank to avoid freezing. To accomplish this, a small opening is made through the valve, B, Fig. 7, as shown in the drawing, which allows steam enough to pass for the above purpose, when there is no other outlet, but is not sufficiently large to interfere with the working of the valve in other respects.

The escape valve, P, Fig. 4, being closed and steam let on, no jet can be established nor any water forced into the boiler, the pressure of steam will then be exerted to force its way into the water supply and lateral pipe. A stop valve or cock being placed at some convenient position on the latter, and closed, the steam will pass only into the tank by the opening in the water check valve.

Fig. 7.



It must, of course, be remembered, that after driving steam through in this way for some time, the feed pipe and its contents will become highly heated. It will, therefore, be impossible to start the injector until this very hot water has been drawn through and ejected by the escape valve.

If this precaution is neglected and the full head of steam is given to the injector before the hot water has all been expelled by the light jet, then, there being no condensation in the nozzle, C, Fig. 4, (or an insufficient one) the jet will not be driven into the boiler, but will back up into the supply pipe, and will drive hot water and steam through the supply pipe to the tank, thus re-establishing the conditions securing failure; so that if another attempt is made at once to start the apparatus, it will fail, exactly as before, and so on perpetually, until the water in the supply pipe is no longer hot; an end to be reached in practice, of course, not by waiting until it cools, but by blowing it out, as before directed.

We come, lastly, in connection with these locomotive attachments, to the main check valve. The object of this evidently is to pre-

vent the water of the boiler from running out through the injector, should anything go wrong.

It is, moreover, so constructed that it not only acts as an automatic check-valve, but it is also arranged so that if, by chance, it sticks up and fails to close, it may be forced down into its seat, and turned round so as to remove obstructions. (See Plate II., main check.)

To accomplish these objects the upper part of the valve is provided with parallel plates cast with it, forming, in fact, a rectangular slot in which fits freely a plate suspended from the T slide of the valve stem which ends above in a button. By this means the valve easily rises and falls, being guided by the part of the stem below the valve, but if it should stick up, it may be at once forced into its seat by pressing on the button, or turned round upon its seat so as to grind out any foreign substance without cramping its guiding stem.

This concludes the category of attachments required for locomotives, their connected arrangement and details being shown in Plate II.

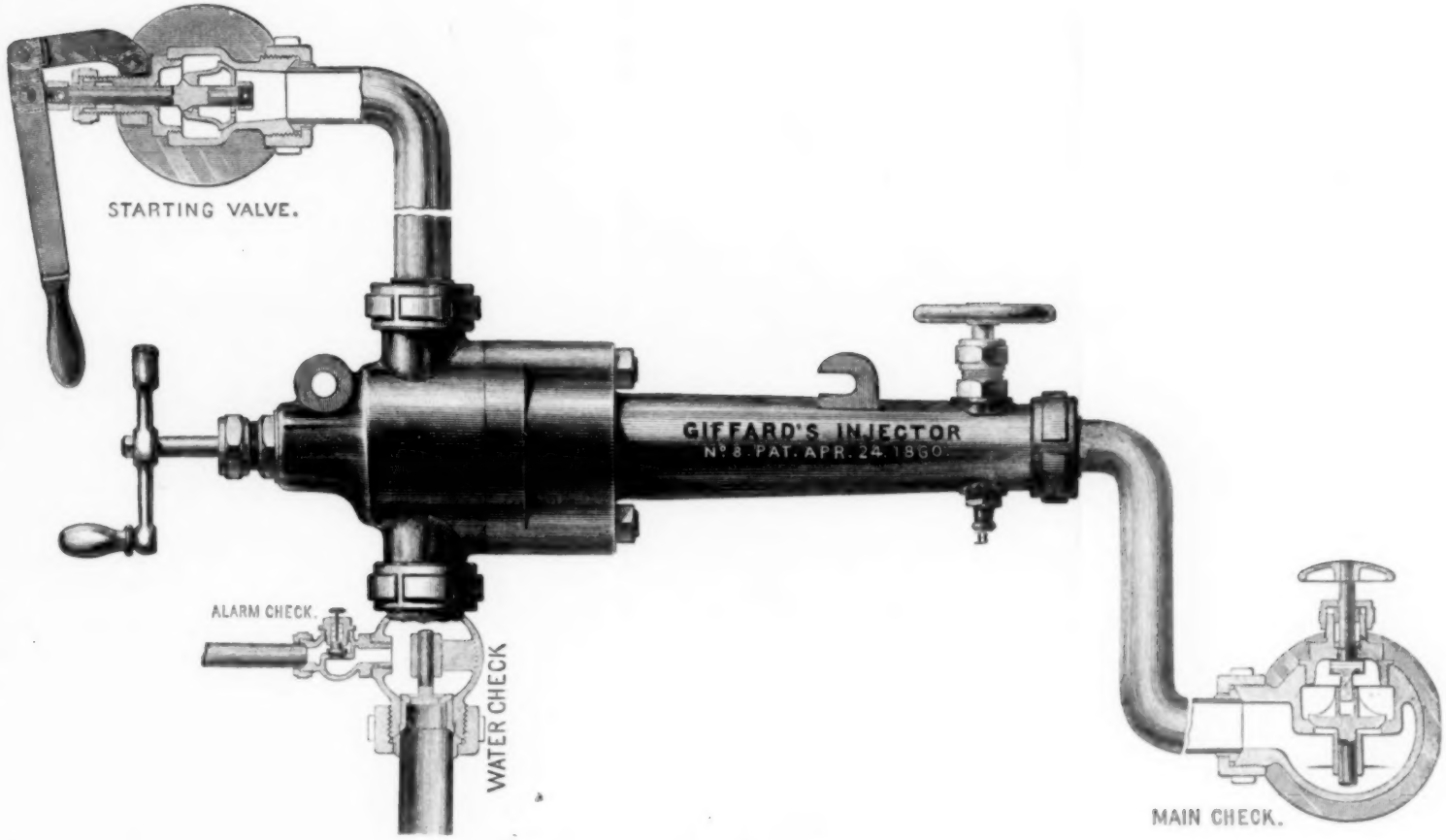
In connection with stationary engines, the only attachments required are the alarm check, main check, and, when there is pressure in the water supply, a water regulator in connection with the water check valve.

This arrangement is shown in plate III. Here we have a sort of balance valve in which the water from the supply, presses upon the inner face of the valve, and also upon the small piston on the same stem, whose outer surface opens to the air through the case. These surfaces are so adjusted that the valve would remain closed by reason of the water pressure, but if a partial vacuum is produced in the pipe, D, by the action of the injector, then the valve will be opened by this force, the amount of its opening being controlled by the position of the stem which is detached from it.

Of course any pressure in the pipe, D, will at once close this valve, so that it acts also as a check valve, which would cause the steam to pass through the alarm check into the waste pipe, so as to attract notice.

With regard to the economy of the Injector, we may look at the subject in a purely theoretical point of view, and reach a conclusion founded upon general principles which we will find to be sustained by the rough, and yet in its aggregate result, still more valuable test, of practical experience.

From what we have already seen in reference to the mode in



LOCOMOTIVE ATTACHMENTS.

which the Injector acts, it appears that the entire force which passes from the boiler in the issuing steam, is returned to it, with the exception of that expended in lifting and injecting the feed-water, and so much as is lost by radiation of heat from the various parts and connections. This is, of course, when all is in proper adjustment.

The steam which escapes, is returned in a condensed form, and the loss of velocity with which it re-enters, represents the force required to raise and introduce the added quantity of water which it carries in with it against the resisting pressure of the boiler. Were any force expended otherwise, it must show itself either as visible motion or as heat. But there is no motion, and indeed, there are no moving parts, and any heat developed in the instrument would be carried into the boiler by the jet, and thus not be lost. We thus see that as a means of introducing water into a boiler, without regard to any accidental modifying conditions, this instrument must be economical, as it only expends the force needed to accomplish the work; whilst in all forms of pumping apparatus a loss of power is occasioned by the friction of various parts, and by their intermitting motion requiring a column of water at rest, and the reciprocating parts of the machine itself to be put in motion at every stroke.

If, however, in some particular case, the comparison is made between the Injector using relatively cold water, and some other means of feeding, combined with apparatus for heating the feed-water by waste heat, the Injector loses its absolute theoretical advantage, to a certain degree. It then depends for its title to superiority upon its convenience and simplicity of structure, which relieve it from expensive repairs and from the risk of derangement and consequent stoppages of works, to which the wear and tear of various moving parts, with their peculiar reciprocating action upon an incompressible material, renders pumps especially liable.

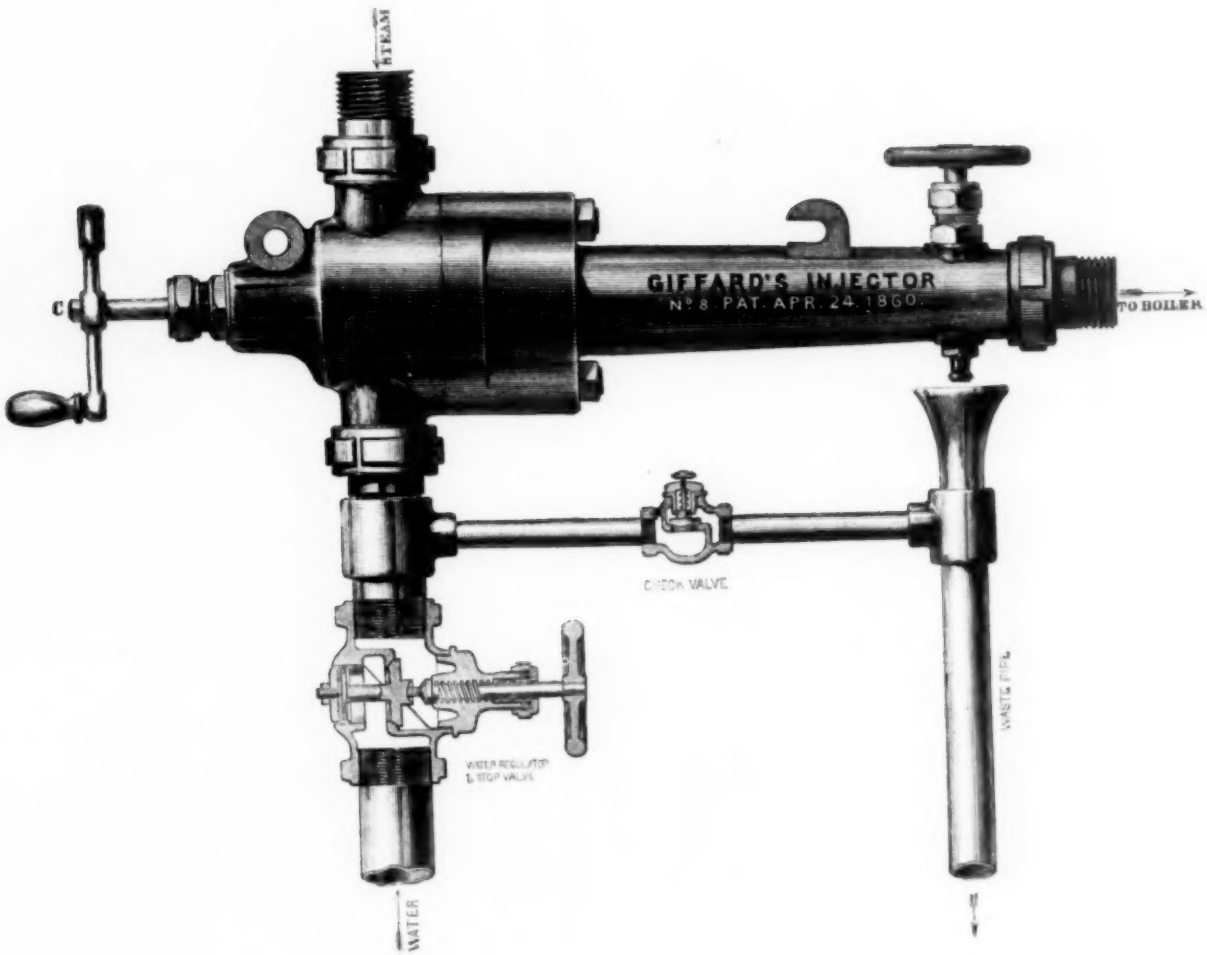
That the loss of absolute theoretical advantage in the Injector, compared with a combined pumping and heating apparatus is *in fact*, slight, will be evident when we remember that with the Injector, as with other means of feeding, waste heat may be employed to act upon the water between the feeding apparatus and the boiler, the difference being simply this: that with a pump, for example, the water will pass into this heating apparatus at its natural temperature and will get *all* the heat it acquires before entering the boiler

from the waste heat, while in the case of the Injector, the water in passing through that instrument, will acquire a certain amount of increase in temperature at the expense of the steam from the boiler before it comes in contact with the waste heat. This fraction, then, of the supply which might otherwise be derived from waste heat, is all that is sacrificed by the Injector.

We therefore conclude, that in all cases in which the feed-water is not heated by using heat otherwise wasted, the Giffard Injector is, to use the words of an eminent French writer, M. Ch. Combes, Inspector-General and Director of the *Ecole des Mines*, "Without doubt, the best of all those hitherto used for feeding boilers, and the best that can be employed, as it is also the most ingenious and simple," * * * * "and is theoretically perfect;" and that even when the comparison is made under the conditions least favorable to itself, this instrument still maintains a practical superiority.

THE MECHANICS OF SPIRITUALISM.—Dr. Peper, of the Polytechnic Institution in London, so well known for his ingenious inventions of the ghost, the floating head, &c., has for some time past employed himself in the development and exhibition at the above named institute of sundry contrivances, by which all the wonders of spiritual manifestations have been not only paralleled but exceeded. One of the most remarkable of these consisted of an arrangement by which various objects and persons were caused to rise in the air and remain there suspended under conditions which implied the impossibility of any supporting wire or thread however fine and invisible.

When, however, we mention that in the patent by which these contrivances are secured to their inventors' use a large plate of glass figures as the "invisible means of support" of these light characters, the wonder of the thing will be somewhat diminished, while the simplicity and ingenuity of the idea may well claim praise. In a foreign scientific journal we see some tricks of the Davenport Brothers, are described and are declared inexplicable, and yet we have repeatedly seen performances, involving every important feature of these *super-human* developments, made by an amateur in the arts of legerdemain in the presence of many spectators, and defying all their ingenuity of detection. Yet to those initiated, these feats are as easily reduced to the domain of nature and mechanics as Dr. Peper's wonders when the glass is recognised.



STATIONARY ATTACHMENTS.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

BY PROF. HENRY MORTON, PH.D.

(Continued from page 136.)

ANOTHER remarkable feature of the lunar structure is, the enormous size of many of its circular mountains or volcanic craters. Thus the largest of these distinct and clearly-defined circles, excluding all the vast wall-surrounded plains, of which we have before spoken, and which are many times larger, is Clavius, near the south pole, whose diameter is 132 miles. We are all familiar with similar distances as traversed by the locomotive and train; but what an idea it gives of the grand extent of the objects we view in the moon, to think of them in such connection. Take, for example, the road from this place to New York, which most of you, no doubt, have traversed. Think how, hour after hour, with the rush of the train, you sweep over meadows and woods—through fields, villages and towns—across land and water. The Delaware, the Raritan, the Passaic—not to mention, perhaps, the Schuylkill, and the Hudson at either end, are crossed—five great rivers, the least of which would float the navies of the world, with all the intervening land and its populous cities, and then, at the end of four hours thus spent, you have traveled a distance which is less by thirty-five miles than the diameter of Clavius, so that we must reach back into another state, and add, say, the distance from Philadelphia to Newcastle, in Delaware, to the other journey, to equal the space we should traverse, could we in like manner glide across that little circle, that barren plain called Clavius, walled in by its rim of precipitous rocks, rising abruptly no less than three miles high, often, in a vertical precipice.

So, again, we have Schiller and Schicard, each about 120 miles in diameter, and Maginus (4) 80 miles; Longomontanus (5) 70 miles; Maurolycus (15) 81 miles; Walter (17) 80 miles; Arzachel

(25) 70 miles; Alphons (30) 91 miles; Albategnius (50) nearly 80 miles; Ptolemaus (31) 80 miles, and a great number of others of like dimensions; while referring to some more familiar objects, we find Tycho, Copernicus, Archimedes (41), and Plato, all from 40 to 50 miles in diameter.*

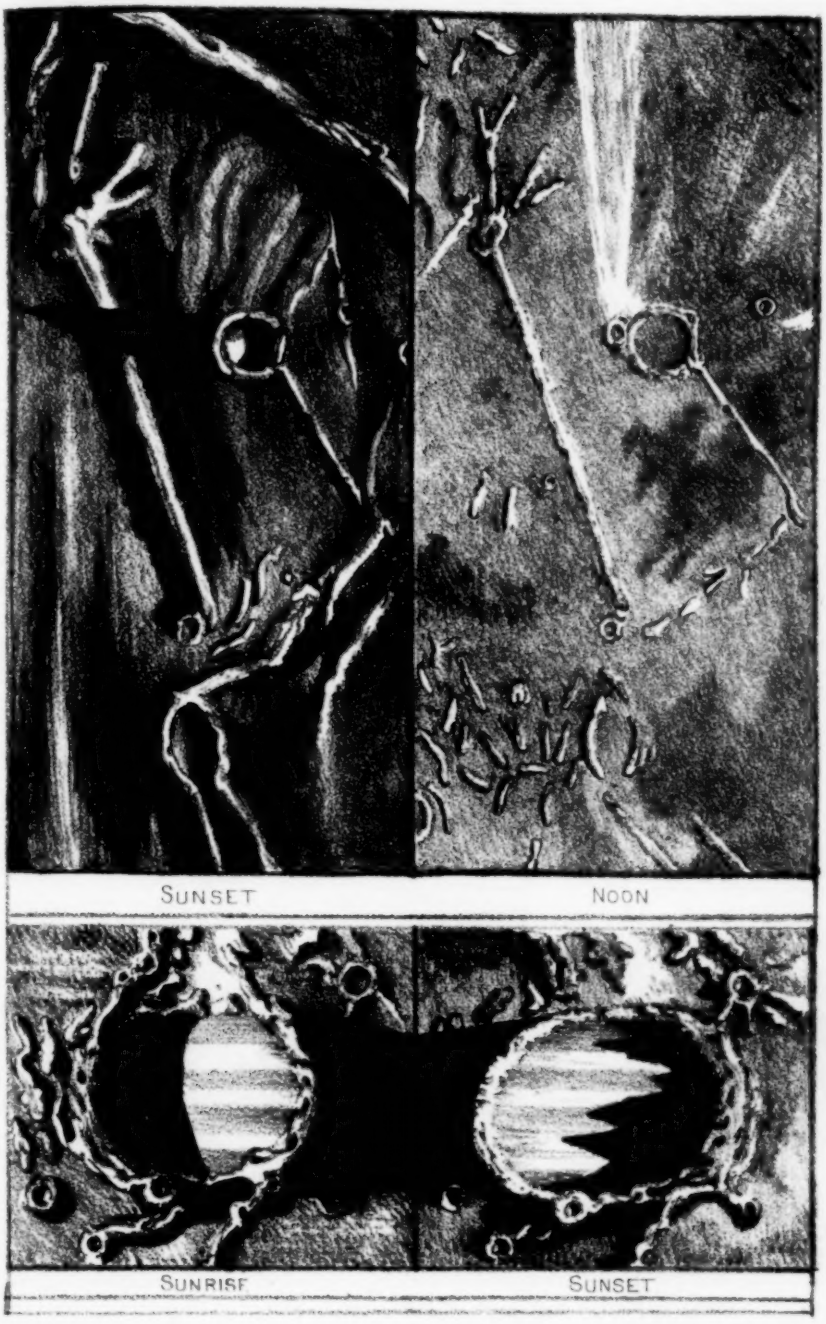
The cause of this stupendous size in the lunar craters is not difficult to find, and seems, evidently, to lie in the three following conditions. If, as is natural, we suppose the moon to have been at first in a fluid state, and to have cooled by exterior radiation, the rapidity with which that chilling would have been effected would be very great, both on account of the large proportion of the surface to the mass, as compared with the earth for example, and because of the absence of an atmosphere, which, as Tyndall has shown, is of immense importance as a means of arresting the escape of heat. This would have made the volcanic actions (supposing these to result from the cooling and contraction of the outer shell upon the fluid nucleus,) very violent. Then, in consequence of the less mass of our satelite, gravitation on her surface would be but one-fifth as great as on the earth, by reason of which, matter projected from a volcanic outlet, would have been driven to a great distance; and, lastly, the absence of an atmosphere, relieving all projectiles of atmospheric resistance would greatly extend their range of flight, and thus cause them to be deposited at a great distance from the centre or vent.†

Many of the same causes which are concerned in the enormous lateral magnitude of the lunar volcanoes, are likewise involved in the development of their relatively vast and precipitous height.

The greatest height attained by a lunar mountain, is that exhibited by Newton, whose peak only is shown in our map, Plate II., lit by the sun (rising on that portion of the planet,) under the letter h, of the word "south." Its height is about 4½ miles. This is an actual elevation less than that of many terrestrial mountains above the level of the sea; but when we compare the relative sizes of the globes on which these peaks occur, we see that their diameters

* The numbers in brackets refer to the locations similarly marked on Plate II.

† The effect of atmospheric resistance on the flight of projectiles, may be well illustrated by the following example which Dr. Young adduces. A musket-ball, with an initial velocity of 1670 feet per second, would have an horizontal range of about five miles in vacuo, but, in fact, reaches but one mile in the air.—Young's Natural Philosophy, Vol. I., p. 30.


SUNSET
NOON
SUNRISE
SUNSET

being as 4 to 1, our terrestrial mountains should be 18 miles in height, to equal those of the moon.

It is true, that we do our own peaks an injustice, by measuring them from the surface of the ocean, while with the moon, there being no water, and so no ocean surface, we measure from the very abyses of its unfilled valleys; but even then we should have only a height of 10 miles on the earth to match with an equivalent one of 18 miles from the moon.

You might naturally inquire, in this connection, how it is that we can measure so precisely the height of lunar mountains. I answer, simply by measuring the length of the shadows they cast in known positions of the sun. From the perfect blackness and sharply-defined terminations of the lunar shadows, this measurement is not difficult, and enables us, beside, to note with great certainty the actual profile and true topographical conditions of the lunar surface, where otherwise we might be deceived by the effects of that difference in reflecting power, to which we have before alluded.

These facts and conditions are well illustrated in Plate III. The two upper drawings are taken from Liais' beautiful work, entitled "l'Espare Céleste et la Nature Tropicale," and represent the same location (a range of hills and volcanic cones in the Mare Nubium) as seen near sunset, and near noon of the lunar day.

It will be there seen how the shadows of sunset bring out the inequalities of level and obliterate the various markings not produced by such a cause, but resulting simply from unequal reflecting power. This is specially notable in the right-hand upper corner of the sunset view: a range of hills appears clearly marked, which was imperceptible in the noon picture; while on the other hand the rays which at noon show clearly from the volcanic ring, are all gone in the evening.

The lower pictures on the plate are from an admirable little book by Guillemin, entitled "La Lune," and represent a volcanic crater as seen at sunrise and sunset.

We there see from the shadow projected on the interior plain, that the right hand or western edge consists of a series of precipitous peaks, while the eastern one is a level rampart. (These drawings, like Plate II., show the objects as seen in the telescope, therefore, inverted, as compared with their actual positions.)

(To be continued.)

LECTURES ON VENTILATION.

By Lewis W. Leeds.

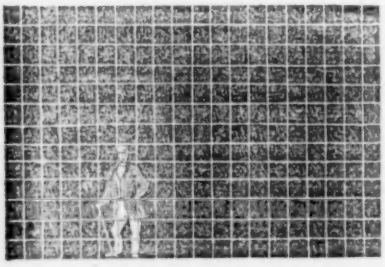
Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 141)

The beating of the pulse is the action of the heart in pumping the blood from the extremes of the body, and driving it through the lungs to be aerated. There are, on an average, about seventy-two pulsations of the heart every minute, and two ounces of blood are passed through the lungs at each pulsation, or from sixty-five to seventy gallons every hour, and from forty to sixty barrels per day. I designed by this piece of red flannel (see cut, Fig. 3) to represent the number of cubic feet of blood passed through the lungs every twenty-four hours.

We thus see the very large amounts of blood and air that circulate through the lungs, and can easily imagine of how much greater importance the proper supply of air is to the maintenance of good health than the supply of food, because, while we eat less than two pounds daily, we breathe fifteen times that amount, or about thirty pounds.

Figure 3.



The amounts here given are only approximations, they are subject to extreme variations.

We all know the wonderful effect of any violent exercise, how it sets the heart to beating, or, in other words, the blood to circulating, this at once requires more air; we begin to breathe faster and inhale and exhale much larger quantities.

It is astonishing how many persons disregard this wonderful provision of nature for keeping off diseases, or for curing it after we have, by our own negligence, allowed it to affect our bodies.

The simple difference in the amount of blood and air which circulate through our systems, under different circumstances, shows us what control we have over our bodies in this respect.

The variation in this circulation from entire repose to vigorous action, may be thirty or forty per cent.—say thirty per cent.—taking the average amount of air breathed at three hundred and sixty-three feet, thirty per cent. of this would be near one hundred cubic feet difference in the amount of the air breathed; and taking fifty barrels as the average amount of blood circulated through the body, thirty per cent. would be fifteen barrels.—Fifteen barrels of blood! coming to the lungs to be purified, to be aerated, and one hundred cubic feet of air, an amount thirty or forty times the bulk of the body, and this the *difference* only, not the actual amount, but just the difference between a state of perfect quiet and that of active exercise.

What a means this is of influencing the condition of the body, and what an incentive to active exertion instead of sluggish, stagnant quiet.

Every child going to school ought to walk two miles in going to school and two miles in the evening in returning home; and no children ought to see the inside of a school-house, until they were quite able to walk that distance in all kinds of weather, without any inconvenience. This positive *necessity* for daily exercise is an advantage, as when it can be avoided it is frequently omitted in stormy and unpleasant weather, much to the injury of the child's health.

It is quite a common idea with many persons, that if they feel unwell in the spring of the year, that their blood must be out of order, it is impure. Now there is but little doubt but the blood of too many persons is very impure, but how do they attempt to purify it? Why by taking some vile compound in the shape of some patent pills, or other miserable stuff.

What would you do with a servant that would neglect to put coal on the fire, and just when she was in a hurry to get breakfast or dinner, finding the fire was nearly out, to make amends for her negligence, should pour turpentine or kerosine on, making a great smoke and a temporary blaze? and probably, if a little careless in its use, would set the chimney on fire, and run much risk of burning the house down.

Well, now, it is just as reprehensible for you to go on all winter neglecting to supply yourself with pure air, and in the spring find yourself weak, debilitated with impure blood, and your fire nearly out, and then to make amends for your carelessness, take some de-

testable pills or some of the world-renowned humbugs in the shape of patent tonics, that, according to the advertisement, are a certain cure for all diseases to which "human flesh is heir." And you might suppose from the reading of these advertisements, that they were an entire and perfect substitute for pure air.

I believe I never was quite so foolish as to take a bottle of any such stuff; but I think there must be a great many who do, from the splendid palaces that are constantly being built from the profits on the sales of such trash.

You might, at first, suppose that physicians, and almost every one else, would have learned by this time the best cure for consumption; yet how generally you find persons with this disease shut up in close rooms, breathing very impure air, and taking extra pains not to allow any *draughts* of any kind to enter the rooms.

I say, you would scarcely suppose it possible that such a contrary course would be pursued; but we must remember how short a time it has been since physicians would not allow the patient to follow the dictates of nature, and drink cold water in fevers.

And most of us remember how common it was, but a few short years ago, to take the very life-blood from a sick person, just at a time when it was most needed in carrying off the disease from the system.

It is not in consumption alone, that fresh air is of such great importance, but it is in all the diseases of the human body. You might, at first, think that in amputating a limb ventilation would have nothing to do with the speedy recovery of the patient, this notion, however, would be a great mistake, as ventilation has more to do with it than any other thing.

The surgeons, during our late war, were fully aware of this, they well knew if they amputated a limb that the death or recovery of the patient depended more upon the air he breathed, than any other agent with which they had to deal.

I remember listening with much interest to the Surgeon General's description of a very difficult case of amputation, which he performed in the field in West Virginia, I think, and he kept the patient with him, (generally in a hospital tent,) and he was getting along most favorably; but was sent finally to one of the hospitals in Baltimore, which I think was an old hotel; soon after which he died. I heard the surgeons say afterwards that they scarcely could cut off a finger in that hospital but the patient would die.

They died from impure blood, they died for the want of ventilation, and this is simply the universal experience of every physician and surgeon.

If I were to scratch my finger, ventilation would have more to do with its healing, than all the salves and plasters I could put on.

It is a very common remark that a cut or wound will not heal because "the blood is out of order." Very sensible remark, too, and the quickest way to get the blood in order is to breathe nothing but pure air and plenty of it.

You have often heard of the woman that wanted some whiskey for a sore toe, but on being remonstrated with for drinking it right down instead of using it to bathe the toe, remarked—"It will soon get there." She was not so far out of the way, either, as we might suppose at first; it would soon get there, indeed, and the inflamed and poisoned blood, I was going to say, would do most as much harm as it does when it gets into the other end of the system; but perhaps that would hardly be possible.

You cannot live without breathing; you cannot live without eating; you cannot live *well* without exercise. These are the three grand essentials for health, comfort and happiness.

The breathing is of more than ten times the importance that eating is. By breathing pure air you can digest more food, and you require more to satisfy hunger.

Some of you may be surprised to hear me assert, that if you cannot get food you would die sooner by breathing pure air, than you would by re-breathing some of the foul poisonous air previously exhaled. I was led to consider this question by the very unexpected results of some experiments I tried last summer with some flies. I took six half-gallon jars, six quart jars, and six pint jars, making 18 in all, into all of which I enticed flies by covering them with bread, with a little molasses underneath. I intended to put two dozen into each jar, but they would not go in just to suit me, so some had 20, some 40 and some 60. Two of the bottles of each size, making six in all, I filled with my breath, and sealed up tight; two of each size I simply sealed tight, but filled with pure air, and the other six, two of each size, I covered with coarse netting, so as to allow of a free circulation of air and keep the flies confined.

It was in summer, and I closed them up at 6 P, M., the sun about an hour high, I observed their condition at intervals of an hour,

making a note on each bottle. At the end of the first hour those confined in the breath were very stupid, many of them tumbling about from side to side, and none able to fly. Those confined in the pure air were moderately lively, about half of them could fly from side to side, and were just as much at the bottom as at the top of the jar. But a very different scene presented as the others with the circulating air were examined, they were all crowded to the fresh air opening, their feet sticking up through the netting, and there they remained with much persistence, if driven away they would immediately return, and in one, there being more flies than room at the fresh air opening, they had to take turns standing at the window, which reminded me of what I observed at Nashville jail, which was so shamefully crowded and with so little air, that each prisoner was allowed just so many minutes to stand by the little hole that admitted the fresh air, and this was considered so great a privilege, each one waited with the greatest anxiety and impatience for his turn, and they would never miss, night or day.*

So it seemed to be a great privilege with these flies, but I suppose they did not take their turn with so much punctuality.

In two hours some of the flies in the breath seemed nearly dead; the others much the same. At ten in the evening no particular change.

Next morning, at six o'clock, no marked difference; those in the breath a little more stupid, and two or three apparently dead; one or two in the confined pure air about dead, on being put out in the bright morning sun they revived wonderfully; those with the circulating fresh air kept up a perfect humming, and the others revived very much; but few, however, of those in the breath, were able to fly even with this extra stimulus. At ten A. M., I went to town, and at five P. M. returned home. I expected to find all those in the breath dead, and those in the confined pure air about half dead, and those in the circulating pure air as lively as ever; but to my utter astonishment and disgust, I found every one of those in the pure air stark dead, not a vestige of life in a single fly.

Those in the pure confined air were about half dead, and nearly the same proportion of those confined in the jar with the breath. But they did not die even in these with that perfect regularity that I wanted them to do.

* I should state, probably, that upon reporting the condition of this jail to General Rosecrans, then commanding, he had it remedied.

That is to say, where there are twenty in a pint jar, and twenty in a quart jar, and twenty in a half-gallon jar, if those in the pint jar died in twelve hours, I expected those in the quart jar to die in twenty-four hours, and so on; but they did not observe any such regular rules in dying.

But, notwithstanding my great disappointment, I kept the jars and watched them. Those in the breath died a little the fastest; but very soon after I noticed another form of animal life in the shape of maggots, which soon attained the size of the original flies.

Now, as these bottles were perfectly clean and corked air-tight immediately after the flies entered, how did those maggots get there? I leave this for others to answer.

Some of these flies lived ten days, (there would be but one or two in a bottle that lingered so long,) the other animal life lingered some three weeks. These bottles, upon being opened, emitted a horrid stench.

But the bodies of the flies confined in the pure circulating air never had the least unpleasant odor, were never touched by any insect, and three months after their bodies were just as bright and clear as the day they died. Thus, those in the foul air lived ten times as long as those in the pure air. Now the practical lesson this teaches is what I before asserted, that when you breathe pure air you live faster, so to speak; you are much more lively; you use much more exertion; but all this exertion requires power, and universal power requires food.

Now, these flies in the circulating pure air no doubt used more exertion or did more work in the few hours they were living there without food, than did those which lived ten days—their bodies were so thoroughly used up, there was nothing but skin and bones left.

This explains what might otherwise seem a strong argument against breathing pure air.

We find some poor, delicate creatures living on to be thirty, forty, fifty, sixty and even seventy years old, and appear to be a perfect refutation of all regular physiological rules; but what sort of lives *do* they live? They cannot do a quarter of a day's work, they can scarcely eat a quarter of a full ration, and if they have existed to an old age they oft-times have scarcely done the work of a quarter of a lifetime.

And thus we find many poor people living in poor, unventilated

houses, *exist* sometimes to quite an advanced age, but they are often sick and feeble.

Therefore, when a person finds he cannot earn his living, or if he does earn it he is sure he cannot get sufficient food to eat, he had better imitate the hybernating animals as nearly as possible, and get into some close, unventilated place and lie down in perfect quiet and repose—and not fret at all and he will then be able to get along on as little food as the most angelic of our fashionable belles could desire to boast of.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

(Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.)

(Continued from page 351.)*

My last paper on the present subject, closed with a proposal to set forth a typical curriculum for a *scientific* institution, possessing a university character, in the American sense, of containing a circle of professional or technical schools, based upon a fundamental disciplinary course, mainly composed of scientific studies. But, in writing, as now, in a summer resort, away from necessary material for reference, it is impossible to do this. Besides, it appears by trial, that various preliminary matters yet remain, to be touched, at least.

We must first introduce a few elements of philosophy, yet so condensed as to be, so to speak, conveniently portable for ready use.

Fact is whatever really *is*, in distinction from what *might be*, or *is supposed to be*.

The two great comprehensive and antagonistic facts of existence, are good and evil.

Good is perfection of *structure*, *action* and *possession;* or, in other words, of *being*, *doing* and *having*. External possession, or having, is *objective* good, and in its perfection is the source of the utmost degree, and highest kind of the *enjoyment* derivable from external things. It is thus a natural stimulus, or source of inspiration, which reacts upon the *being* and thence upon the *doing* of

* *Correction.*—On p. 349, line 12, read "industrial."

the happy possessor. The *acquired* mental powers resulting from worthy *doing*, are one's *subjective having*, and the most precious of his acquired possessions.

BEAUTY is not something else than good, nor a mere attribute of good, but a certain *relation* of it. It is, we venture to say, *good, considered as spontaneously self-expressive*, whether living or abstract, spiritual or material, partial or complete. Thus, when we say that one's spirit or life is full of beauty, we mean that it is not something unknowable, hidden, and incapable of self-revelation, but something open and readable, which of *itself alone*, that is, freely, unconsciously, reveals itself as good.

The rare subtlety and elusive delicacy of the idea of beauty makes it unsafe to risk a bare definition of it, unsupported by illustration. We therefore dwell upon it for a moment in the latter way. And as spiritual beauty is of the highest order, a simple study from life may afford an acceptable illustration.

The ideal of a man is that he should be the perfected, the ripened sum of all his previous states. When, then, I look into the face of my speaking friend, and there clearly see retained, amidst and under firmer lines and tones of growing maturity, all the freshness of life and ardent delight in it, and the truthfulness and gentleness of sunny childhood and gay boyhood, I delight in the beauty consisting in the spontaneous expression, in his case, of the ideal good mentioned; and, as in the definition, the degree of beauty depends on the fullness with which that truth reveals itself, in this case, on the extent to which the man has retained his true boyhood in and as part of his true manhood.

In like manner, when any inanimate object is called beautiful, it is meant that it suggests or expresses elements of good actually or possibly in the *being* and mental or manual *working* of the designer and maker on in life generally. Thus, a partially concealed discord, naturally leading, according to the laws of harmony written upon the mind, to a full, rich, and perfect concord, expresses the *good* of temporary and unpromising conflict, resolving itself to the heart of hope and faith into a happy conclusion. Again: the horizontal direction, with the great weight of the main branches of an oak, suggest the *good* of vigorous, inward might, abundantly adequate for self-support under the greatest stress of circumstances and pressure of outward conditions. Moreover, both of these expressions of particular forms of abstract good, or good elements of being or life, further suggest a living one; as the composer of the harmony by

whom the elements of good expressed were conceived of and appreciated, or in whom, as in the creator of the oak, they resided.

TRUTH is good considered as universally agreeing with itself in all its forms, so that when one form exceeds the point up to which it graces or assists some higher good, it then ceases to be a good. Otherwise: truth, abstractly, is agreement with fact; in life, it is thought, action, expression, agreeing with fact.

RIGHT is the means for the attainment of good; the path to attainable good. To handle any tool in the *right* way, is to handle it so as to accomplish what the tool is meant to accomplish. And actions, generally, are *right* when they serve to perpetuate or produce any real good.

Thus *good* is the grandest and most central of all abstract terms, and one to which the trio, *true*, *beautiful* and *right*, cling in close and happy relation.

Passing now from these abstract elements to the life in which they are to be realized, we have to consider the outlines of the constitution of man, that we may have in mind some guiding principles in composing a course of studies for the training of his being.

Man is primarily a union of matter and mind, of body and spirit, and *such* a union that the highest earthly well being of each is involved in that of the other. Moreover, as the bodily wants are earliest expressed and most immediately imperative, we have in this fact the sure ground for the instinctive demand for the sound body first, as the due lodgment and instrument, too, of the sound mind.

The body being at once the temple and servant of the ministering and governing spirit, the elements in the latter are chief in interest and importance.

In the spirit there is found, fundamentally, *conscious life*, with *reason*, or the sense of first truths, or axioms and primary ideas, as of space, &c., for its appointed guide, and will, or the power of choice, as its appointed sovereign; that is, in both cases, as against the mere declaration or dictation or interference of other like spirits, but ever in unmingled deference to the Supreme Creating Spirit.

Within the reason are *common sense*, by which, for lack of another term, is here meant the sense of the distinction of true and false; *taste*, or the sense of the distinction of beauty and ugliness; and *conscience*, often expressly called the moral reason, or the sense of the distinction of good and evil, and of right and wrong as the means to each.

(To be continued.)

Bibliographical Notices.

Lessons in Elementary Chemistry, Inorganic and Organic. By Henry E. Roscoe, B. A. F. R. S., Prof. of Chemistry in Owen's College, Manchester. Published by William Wood & Co., 61 Walker Street, New York. Lindsay & Blakiston.

This work is a re-print from the English edition, of which a brief but rather *severe* notice was made in this *Journal* some time since, by one of our contributors.

The present publishers have followed, in style and general arrangement, the foreign edition, but seem to have taken more care with the execution of the work. Thus, while the engravings are as unartistic and rough as before, the paper and printing are excellent.

The book is of a convenient size, is neatly bound, and very suitable as a text-book on chemistry, according to the new theory and nomenclature.

It is arranged somewhat on the inductive method; laws and theories being distributed here and there, as developed by the facts and reactions discussed. According to our own notion, this is less efficient for purposes of instruction, than a systematic arrangement of laws first, and facts afterwards; but this is a subject on which great diversity of opinion exists, and our author has abundant support in the way of example in his view of the subject. For those desiring a concise compendium of elementary chemistry in its new shape; this work will prove very useful.

A System of Instruction in the practical use of the Blow-pipe; being a graduated course of analysis for the use of students and all those engaged in the examination of metallic combinations. Second edition. With an appendix and a copious index. By G. W. Plympton, A. M., Prof. of Physical Science in the Polytechnic Institute, Brooklyn. Published by D. Van Nostrand, 192 Broadway, N. Y. J. B. Lippincott & Co.

In addition to the title given at length above, it is only necessary to state that this book is brought out by its publishers in a good substantial form, and that it differs from the classical works on this subject, such as those of Berzelius and Plattner, chiefly in a greater simplicity and compactness, and in the introduction of the latest

discoveries and new modes of testing, which have been applied in blow-pipe analysis.

The work is, as its author states, chiefly a compilation from Scheerer and Plattner, which shows it to be reliable, and is evidently well arranged; while the fact of its reaching a second edition in a year, speaks highly for its usefulness and value in the eyes of those most interested.

The Gas Works of London. By Zerah Colburn, C. E. Published by D. Van Nostrand, 192 Broadway, New York. For sale by J. B. Lippincott, Philadelphia.

This little book of some 86 pages, is of course far from being a thorough treatise on the important industry of gas manufacture, but it does contain much special and exact information on the details of the process, not included in any other book.

It is, in fact, a reprint of certain articles published in *The Engineer* during 1862, with additions and re-arrangement. Being thus prepared by one on the ground, and furnished equally with the means of acquiring exact information, and the ability of giving expression to the facts obtained, it could not fail to be what its perusal demonstrates it, a work of great value to all engaged in the business of which it treats.

A Treatise on the Metallurgy of Iron, containing outlines of the history of iron manufacture, methods of array and analysis of iron ores, processes of manufacture of iron and steel, &c., &c. By H. Bauerman, F. G. S., Associate of the Royal School of Mines. First American edition revised and enlarged; with an appendix on the Martin Process for making steel, from the report of Abram S. Hewitt, U. S. Com. to the Universal Exhibition. Published by D. Van Nostrand, 192 Broadway, New York. For sale by J. Pennington, Philadelphia.

We can cordially recommend this volume as a full and concise discussion of the subjects enumerated above. Containing but 400 small octavo pages, it of course does not compare in fullness of detail and extent of discussion with such a work as Percy's; but for that very reason will commend itself to many who do not care to study the *history* of the various improvements in iron manufacture, but are contented with the results, and to whom the relatively trifling cost of this work would be an object.

The Institutes of Medicine. By Martyn Payne, A. M. M. D., L. L. D. Eighth edition. Harper & Brothers, New York. Lindsay & Blakiston, Philadelphia.

This work is one of great size, containing 1,145 quarto pages, and that it should have reached eight, and in fact, nine editions (two editions notably different, having by some chance been published as the seventh), is a valuable and irrefutable testimony to its worth.

The subjects treated in this work are not such as we feel ourselves competent to discuss, and we therefore leave the matter with the above statement as embodying the practical and sincere judgment of those most competent and interested during past years, and simply add that the work has been put in excellent and substantial form by its present publishers in this edition, with respect to paper, typography and binding.

The Merchants' and Bankers' Almanac for 1868. Price two dollars. Published at No. 41 Pine Street, New York.

Contains the monthly prices for forty years, at New York, of the following articles:

Bar iron, sheet iron, pig iron, pig copper, anthracite coal, coffee, cotton, wool, wheat, rye, corn, oats, hops, molasses, sugar, pork.

The grain products (quantity, acreage and value) of every State in the Union—corn, wheat, rye, oats, barley, buckwheat, potatoes, hay and tobacco—years 1865, 1866.

Also, the monthly prices of ninety staple articles at New York, 1867.

Also contains:—1. List of 1,650 National Banks; 300 State Banks; 1,400 Private Bankers in the United States; Banks and Bankers in Canada; 1,200 Bankers and Brokers in New York City, including names of members of the New York Stock Exchange. 2. The Open Board of Brokers. 3. The Gold Board. 4. The Mining Board; Annual Reports on Banks, Coinage, and ninety Staple articles; Capital, Circulation and Profits of each Bank in New York City. Also, a list, recently compiled, of the Marine, Fire, and Life Insurance Companies in the United States (eight hundred and twenty-seven in number), with the names of President and Secretary of each, and the capital (or assets) of each in 1867. The daily price of Gold at New York, 1862 to 1867; Alphabetical List of 2,000 Cashiers; and Engravings of New Bank Buildings.

A COMPARISON *of some of the Meteorological Phenomena of* JULY, 1868, *with those of* JULY, 1867, *and of the same month for* EIGHTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	July, 1868.	July, 1867.	July, for 18 years.
Thermometer—Highest—degree	98·0°	91·6°	101·0°
" date	14th.	4th.	17th, '66.
Warmest day—mean	90·50	85·67	92·33
" " date	14th.	4th.	17th, '66.
Lowest—degree	65·00	58·00	53·00
" date	28th.	14th & 19th.	2, 3, '62: 3, '57
Coldest day—mean	71·50	66·67	59·70
" " date	27th.	20th.	3d, '57.
Mean daily oscillation	13·32	14·69	15·42
" " range	3·13	3·99	3·81
Means at 7 A. M.	77·26	72·00	73·99
" 2 P. M.	86·60	81·27	83·70
" 9 P. M.	80·79	75·00	76·58
" for the month	81·55	76·09	78·09
Barometer—Highest—inches	30·163	30·249	30·249
" date	1st.	14th.	14th, '67.
Greatest mean daily pressure	30·141	30·243	30·243
" " " date	1st.	14th.	14th, '67.
Lowest—inches	29·623	29·665	29·443
" date	25th.	21st.	19th, '51.
Least mean daily pressure	29·719	29·698	29·462
" " " date	25th.	21st.	30th, '56.
Mean daily range	0·064	0·097	0·092
Means at 7 A. M	29·962	29·941	29·844
" 2 P. M	29·928	29·912	29·815
" 9 P. M	29·942	29·916	29·831
" for the month	29·944	29·923	29·830
Force of Vapor—Greatest—inches	0·911	0·925	0·983
" date	12th.	6th.	26th, '54.
Least—inches	·507	·821	·255
" date	27th.	18th.	22d, '64
Means at 7 A. M	·705	·552	·614
" 2 P. M	·732	·543	·610
" 9 P. M	·752	·608	·644
" for the month	·729	·568	·623
Relative Humidity—Greatest—per cent	90·0	91·0	97·0
" date	23d.	27th.	Often.
Least—per cent	39·0	32·0	26·0
" date	13th.	3d & 18th.	23d, '56.
Means at 7 A. M	75·3	68·9	72·3
" 2 P. M	58·3	50·5	52·8
" 9 P. M	71·6	69·2	70·0
" for the month	68·4	62·9	65·0
Clouds—Number of clear days*	5·	14·	7·6
" cloudy days	26·	17·	23·4
Means of sky covered at 7 A. M	72·6 per ct	52·2 per ct	58·7 per ct
" " " 2 P. M	65·2	59·3	59·3
" " " 9 P. M	64·5	43·2	42·8
" " for the month	67·4	51·6	53·6
Rain—Amount—inches	2·63	3·030	3·534
No. of days on which rain fell	9.	12·	10·9
Prevailing Winds—Times in 1000	s 15° 15′ w. 131	N 69° 35′ w. 208	s 75° 39′ w. 166

* Sky one-third or less covered at the hours of observation.

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EDITORIAL.

ITEMS AND NOVELTIES.

Soda Water Apparatus.—We spent an evening very pleasantly, some weeks since, at the Conversazione of the American Pharmaceutical Society, which was held in the new building of the College of Pharmacy in this city. Among the many pieces of apparatus and products of manufacture exhibited on that occasion, nothing will, we think, be of more interest to our readers, than the various machinery connected with the manufacture and storage of soda water (so called), or more strictly water holding in solution carbonic acid under pressure. The most complete collection of this apparatus, was that sent by Mr. John Matthews, of New York, and we shall proceed to describe some of the more prominent features and interesting novelties there represented.

When the father of Chemistry, Dr. Priestly, writing about 1772 (see his "Experiments on Different kinds of Air," Vol. I. p. 52), sug-